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Estimating the ROI on Implementation of RFID at the Ammunition Storage Warehouse and the 40th Supply Depot: KVA as a Methodology

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December 2009

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The purpose of this project is to estimate the Return On Investment (ROI) on implementation of RFID (Radio Frequency Identification) in the Ministry of National Defense (MND) inventory management context by using the KVA (Knowledge Value Added) theory. The MND has not only experienced continuous pressure from the government to reduce costs, but has also tried to improve productivity. To meet this challenge, the MND has tried to adopt various new management techniques and technologies to improve the operational performance, cost-effectiveness, and ROI. Accordingly, the authors will use the performance measurement methodology, the KVA approach to estimate the ROI in one of these new technologies, i.e., RFID. The KVA methodology may prove to be a very useful tool for the MND. In particular, this framework will give decision-makers an idea of how an investment in RFID to support a redesigned inventory management process is paying off. The KVA also provides management with a way to help manage costs. This tool can be also applied to other areas in the MND to assess the potential ROI of new techniques and process redesigns before implementing them.

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LIST OF ABBREVIATIONS AND ACRONYMS

AP	Access Point
APT	Arbitrage Pricing Theory
ASW	Ammunition Storage Warehouse
BSC	Balanced Scorecard
CAPM	Capital Asset Pricing Model
DIS	Defense Information System
DoD	Department of Defense
GDP	Gross Domestic Product
KAU	Korea Aerospace University
KIDA	Korea Institute of Defense Analysis
KVA	Knowledge Value Added
LCC	Life Cycle Cost
MEMS	MicroElectroMechanical System
MIC	Ministry of Information and Communication
MND	Ministry of National Defense
NPV	Net Present Value
NSWC	Naval Surface Warfare Center
OIF	Operation Iraqi Freedom
PDA	Personal Digital Assistants
PEC	Performance Evaluation Conference
PMT	Performance Measurement Tool
RFID	Radio Frequency Identification
RF-AIS	Radio Frequency – Ammunition Information System
RMMS	Reference Material Management Service
RO	Real Options
ROI	Return on Investment
ROK	Return on Knowledge
SME	Subject Matter Expert
SPSS	Statistical Package for the Social Sciences
UID	Unique Identification

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I. INTRODUCTION

A. PURPOSE/PROBLEM STATEMENT

According to the Reform of Defense 2020 plan, the Ministry of National Defense (MND) seeks to construct a high-tech military that can reduce overhead cost and improve productivity. The KVA methodology can measure both of them.

The MND has implemented RFID technology at seven Ammunition Storage Warehouses (ASWs) and five Air Force Supply Depots since October 2004. Over the past five years, seven ASWs and five Supply Depots have implemented RFID technology. However, the problem is that there are no objective ways to determine the Return On Investment (ROI) of RFID.

Over the past few decades, there have been many attempts to estimate the cost benefit of these kinds of technologies. The most representative method of Performance Measurement Tool (PMT) is the Balanced Scorecard (BSC) based on critical success factors and key performance indicators. The MND has referred to Jung's (2007) paper of the Korea Aerospace University (KAU) using the BSC to estimate the performance improvement on implementation of RFID. However, the journal Performance Measurement Association (PMA) believes that the failure rate of this approach is around 70%, which begs the question of the viability of measurement of RFID for the MND (H. Counet, 2005).

B. BACKGROUND

For many years, the United States has had problems with tracking and identifying inventory during combat operations, most recently in Operation Iraqi Freedom (OIF), incurring an average loss of $3.5 billion.

> In OIF, nearly forty thousand containers from hundreds of different suppliers, contractors, vendors, and the Department of Defense itself found themselves placed in massive battlefield supply depots. In Saudi Arabia alone, 6.5 million tons of equipment arrived in-country. Those forty thousand containers arriving in theater created a time- and manpower-intensive job as inspectors were forced to empty and repack container after container in search of the parts that they required. More than half of the containers were never opened and left in the "Iron Mountains" of

> containers stacked up outside the ports. This lack of control of the supply system caused commanders to order the same parts several times, and in Operation Desert Storm resulted in $2.7 billion dollars worth of parts going unused and sitting in the Arabian desert for months and sometimes years (Jones & Davis, p. 229).

The MND has the same problem. The MND has implemented the Defense Information System (D.I.S) for military asset visibility since 1996. However, the RoK logistics had suffered from wasting money due to excess demand that came from the ignorance of the amount of inventory and military items stored in the warehouse (Alan, & Steve, 2004).

RFID implementation is one of the solutions to eliminate this problem. This new technology promises to reduce the cost of war, as indeed RFID is regarded as the most powerful logistical system in the private sector, and in public organizations such as the MND as well (Jones, & Davis, 2004).

In the case of MND, the inventory tracking and prevention of loss of goods are also important since the MND has been under pressure due to government budget cuts over the past decades. Per Reform of Defense 2020, the MND is re-structuring toward technology intensive forces, which means that they have to focus on the efficient management of limited resources. Accordingly, the MND sought to improve productivity using high technology, e.g., RFID, and thereby reduce costs. For example, the MND implemented RFID technology in a variety of fields such as the Ammunition Storage Warehouse (ASW) and Air Force Supply Depot.

RFID is a revolutionary technology for improving the ability to track supplies, which will reduce cost and decrease loss of goods. However, it is imprudent to adopt the technology blindly, without considering all factors such as revenue and cost. Normally, new technology that will be able to improve the efficiency of the process is costly and demands a high budget. Accordingly, when it comes to planning implementation of the new system, it is tremendously important to assess the new technology's ROI so as not to waste money. For the MND, which has been under pressure from the government to slash its budget, it is important to estimate the scalable ROI to demonstrate prudent spending.

Private sector businesses have estimated the ROI at the corporate level. However, the problem is that they tend to assess the ROI by only considering cost and they do not take the revenue into account in assessing the ROI[1]. The MND convened a Performance Evaluation Conference (PEC) in 2005 to measure the performance improvement of IT based on the survey results. As will be explained in greater detail below, Jung (2007) used a BSC approach to assess respondents' perception of the process improvement followed by the implementation of RFID in the ASW. The authors will contend that his approach does not capture ROI (K. S. Lee, 2004).

In this project, the authors intend to suggest the KVA theory as a tool to quantify the ROI by doing proofs of concept on two cases: ASW and Air Force 40th Supply Depot. Hopefully, this project will provide decision-makers in the MND with a notional hurdle rate [2] to make decisions on whether they should proceed with RFID investments (C. S. Park, 2007)

Typically, a hurdle rate is based on a conservative rate of return such as the risk-free rate compared to the internal rate of return of a given project. In this study, the authors are using a notional expectation that the ROI of projects where RFID was implemented. This represents a departure from the normal definition of hurdle rate but is used here to set expectations for ROI on RFID projects at a higher level. This provides a more aggressive expectation for the performance of this technology in new projects.

The methodology used in the present study, i.e., knowledge value added, allows the generation of value-based comparables for the purposes of establishing an objective return on investment measure that is not based solely on cost; rather, it is based on an objective and defensible metric of revenue or benefit that is comparable to and can be calibrated with the market. Coupled with risk analysis, this method can be used to measure the return on investment for a certain project and therefore, using such an approach, the authors can replicate the methodology for multiple projects to generate a portfolio of projects. Similar to the Capital Asset Pricing Model (CAPM) or Arbitrage

[1] ROI = (Revenue-Cost)/Cost.

2 In business and engineering, the minimum acceptable rate of return, often abbreviated MARR, or hurdle rate is the minimum rate of return on a project a manager or company is willing to accept before starting a project, given its risk and the opportunity cost of forgoing other projects (C. S. Park, 2007).

Pricing Theory (APT) methods, this portfolio serves as a proxy for the market, and based on the levels of risk involved in each individual project, the authors can similarly determine a relevant hurdle rate and required rate of return threshold.

Discount rate, hurdle rate, and required rate of return are all related concepts used in investment decision making pertaining to return on investment of a certain project. A discount rate is typically applied in a discounted cash flow model to take into account varying risk levels of different projects and discount them at the appropriate risk-adjusted rate of return (high risk projects require high returns to compensate for the added risk), in order to arrive at a net present value. A required rate of return is similar to a discount rate in that it is used as a hurdle rate, above which a return on investment justifies investment in a particular project. A discount rate is determined several ways, from a typical Capital Asset Pricing Model (risk-free rate plus an added excess return commensurate with the market premium calibrated to the excess risk involved in the investment) to a Weighted Average Cost of Capital approach (where the total cost of equity, debt and preferred equity are added to determine the actual flotation cost of invested funds) and Multiple Asset Portfolio Theory approach (looking at multiple risk factors and risk premium in the market), whereas the hurdle rate can be determined using any combination of these methods as well as a subjective required return based on investors' or decision-makers' risk preferences, and calibrated with existing or comparable projects (J. Mun, 2006).

C. RESEARCH OBJECTIVES

Even though the MND has tried to adopt high technology and information technology to improve logistics, there is no objective methodology to measure the ROI from mandating new systems and programs. For this reason, the authors want to introduce the KVA theory to the MND as a way to estimate the ROI on potential investments in new technologies.

The goal of this research is threefold. First, the authors will introduce the KVA theory as a framework to estimate the knowledge embedded in Information Technology (IT) in order to assess the Return On Knowledge (ROK) and ROI of this technology. The

KVA methodology, which has not been introduced and used in the RoK, is a simple and inexpensive performance measurement to estimate the ROI of IT. Second, the authors will provide a potential hurdle rate that can be used as a reference in deciding whether to adopt a new technology such as RFID system. Third, the authors will compare the ROI of other RFID case studies based on projected data. However, this project used the real data of implemented RFID systems in the MND and analyzed the data with the KVA methodology.

The third objective will be done by analyzing the potential benefits of the implementation of RFID in the ASW and Air Force Supply Depot by using a KVA methodology. The KVA results through these two proofs of concept can be used to set a hurdle rate, which can be applied to similar MND technology acquisitions; thus, it provides decision makers with a disciplined approach to reach and with budget decisions that can provide better ROIs to the MND.

D. METHODOLOGY

This project will assess the efficiency of RFID technology in military logistics, in terms of process capacity and productivity. This analysis will help evaluate the impact of this IT technology on process improvement and productivity. The authors will model the standard processes and related sub-processes of the inventory warehouse using RFID technology in ASW and Air Force Supply Depot. The KVA methodology will be used to give a hurdle rate in the form of ROI and measure the impact of improved processes and technologies on the current process. For analyzing the sub-process of this model, time-to-learn, number of personnel involved and the number of times each process is performed were utilized. The financial and human resource data used in this model will include actual Fiscal Year 2006 and 2007 data collected from the MND, the Army logistics department and Air Force headquarter of RoK.

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II. LITERATURE REVIEW

A. PERTINENT LAWS

1. Military Reform Plan 2020

Military reform plans were announced in 2005 in order to suggest what strategic vision the MND should be seeking to achieve. For a long time, the innovation of more advanced military reform was continually required due to the declining budgets. The MND seeks an 11.1% increase in military spending per year over the next 10 years, as part of efforts to build more future-oriented forces (I. C. Lim, 2008). This plan focuses on developing the country's labor-intensive force into a smaller but stronger one that is suitable for the next generation of warfare. RFID technology is one of the methods to achieve the MND's goal.

However, the big problem is funding for new technology. In recent years, annual defense budget increase rates have been between 6.3% and 9.9%. Under the plan of an 11.1% increase on a yearly basis, the country will spend a total of 289 trillion won ($281 billion) on its military over the next 10 years. The defense budget is approximately 2.5% of the Gross Domestic Product (GDP). Put simply, a high-tech military force demands a high initial budget. Accordingly, the MND should verify its prudent management of budget by implementing efficient cost-benefit analyses. Figure 1 shows the change of defense budget versus GDP (J. O. Baek, 2007, p. 45).

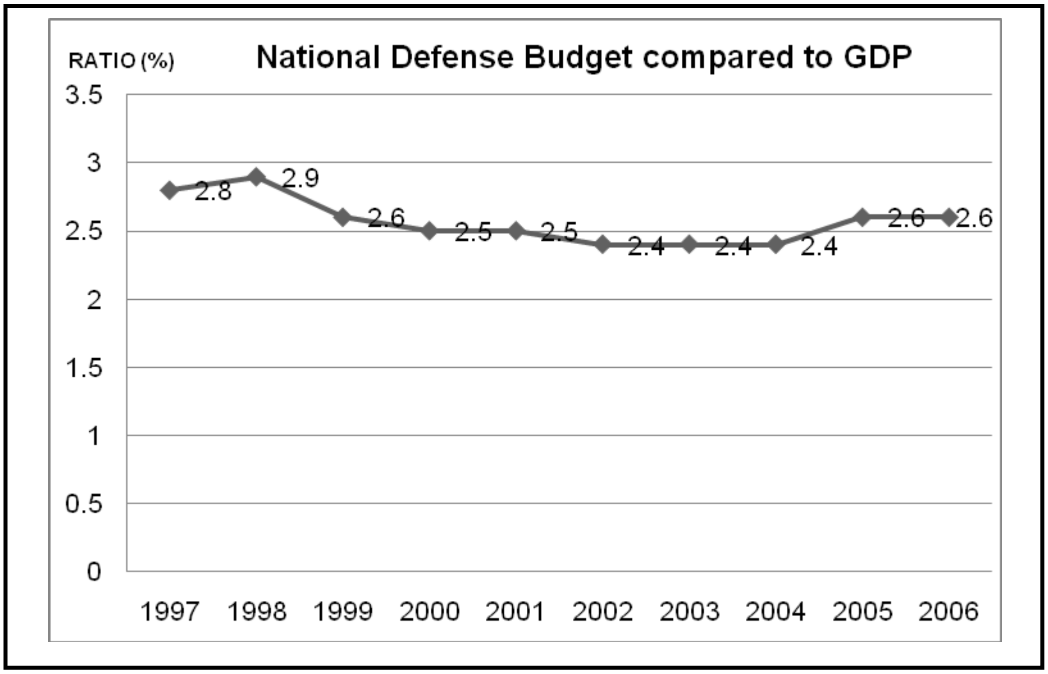

Figure 1. National Defense Budget of RoK (From: J. O. Baek, 2007, p. 49)

Also, most technologies required for an advanced military force are now highly related to knowledge-based technology such as RFID and the defense information web system, etc. As the military weapon systems and military infrastructure move from the industrial era to the knowledge information era, the current accounting systems used to quantify value and cost become less and less applicable to the military environment. There has been no appropriate tool to measure the benefit of the implementation of new IT so far. If the value of knowledge embedded in IT can be measured, then the benefits of the implementation of the IT can be evaluated.

The KVA is a methodology designed to estimate the knowledge value resident throughout core processes including supporting IT. This is the KVA's main strength compared to the other methodologies such as BSC. One benefit of the KVA in this project is that the authors will be able to identify bottlenecks in the process. Then, it can determine which processes to reengineer using new technology such as RFID.

B. CURRENT IMPLEMENTATION OF RFID IN THE MND

1. How to Apply RFID Technology to Support Military Defense Logistics

Since 2004, the MND and the Ministry of Information and Communication (MIC) have collaborated on plans for the construction of U-defense[3] in order to realize the Military Reform 2020 goals. This is a blueprint to apply RFID technology to the public fields such as military logistics. Radio Frequency - Ammunition Information System (RF-AIS) and F-15K parts management through RFID are two of these projects. In particular, the RoK army formed in 2006 a taskforce charged with broadening RFID implementation in the defense field beyond its ammunition inventory system. On top of that, they were seeking to form a roadmap to make full use of RFID technology with a variety of ways to improve their military logistics. The MND is trying to apply various ideas and private sector managerial approaches and technologies that can be adapted to the unique military environment.

a. RF-AIS

The MND operated an AIS to control the whole process of ammunition distribution before using RF – AIS. To be specific, distribution is now automatically processed from the requirement to supply just-in-time by attaching RFID tags to the pallets, boxes and various kinds of ammunitions. This system made it possible to supply the required ammunition to the users as soon as possible, which is an appropriate system to respond to the current operational speed on the battlefield. In addition, this system decreased the job redundancy of ammunition management and saved substantial administrative time (J. H. Lee, 2005, p. 46).

[3] U-defense is the acronym of Ubiquitous defense.

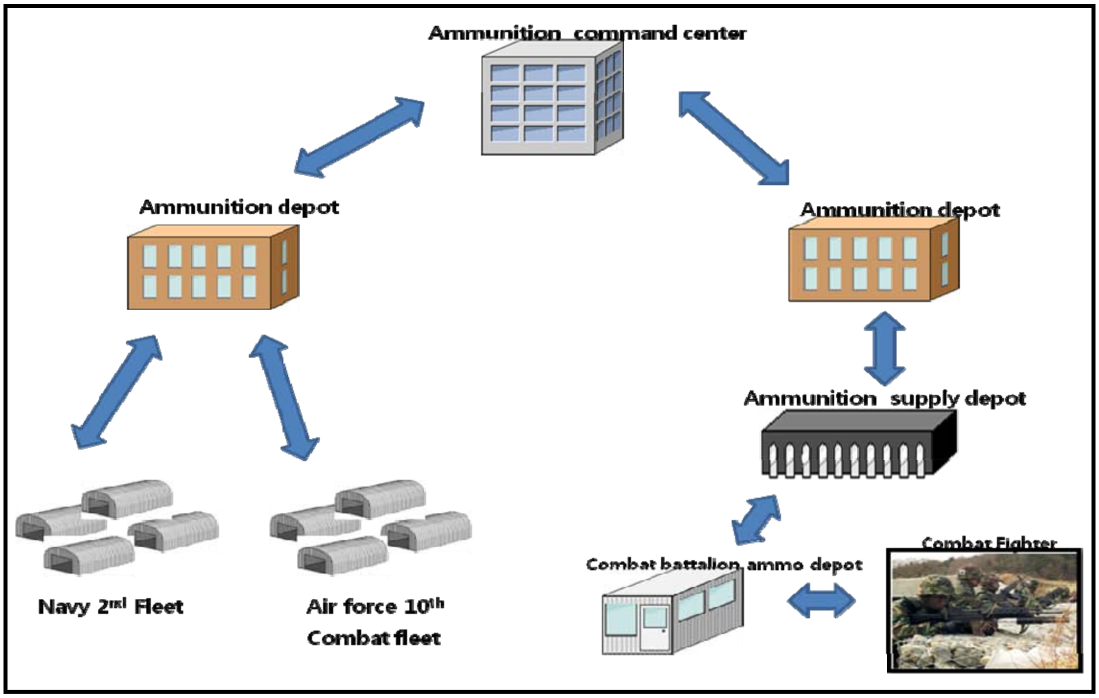

Figure 2. Ammunition Supply Process

The RFID reduced the distribution time, investigation time of ammunition volume, and decision time for release of ammunition. Furthermore, it became possible to manage special ammunition such as grenades by checking the volume in real time. Above all, it was possible to track the ammunition from production to consumption through RFID tags. In other words, the ammunition flow can be tracked in real time and the records of ammunition can be analyzed since the current state of distribution of ammunition is constantly updated in the ammunition headquarters. The MND is trying to attach the RFID tags to all kinds of ammunition bullets and boxes.

b. F-15K Parts Management System

The benefits through RFID used to manage F-15K repair and spare parts are almost the same as the above ammunition management system in the MND. To be precise, RFID technology removed the need to physically confirm transfer at the port of the containers filled with repair and spare parts for F-15K, along with their movement from point ‘A’ to point ‘B.’ Other benefits through RFID include: (1) automation through ‘RFID reader’ on acceptance, handover, and warehousing of containers; (2) convenient

inventory; and (3) decreases in administrative tasks. Furthermore, quantitative benefits are: (1) reduction in administrative time and manpower required to manage inventory; (2) decrease in waiting time for maintenance; and (3) prevention of errors by manual input (Report of Korea Institute of Defense Analysis (KIDA) IT Consulting Group to the MND, 2005).

C. PRIOR RESEARCHS

There were three RFID related projects performed at NPS. These studies projected the potential benefits of using the technology in three different logistics processes, two of which were comparable to the two case studies reported in the current study. The authors will briefly review each of the prior studies in what follows. Then the authors will review the use of the BSC approach as a way to estimate the benefits of using RFID technology in the ASW case at the MND.

1. A Hybrid Approach to the Valuation of RFID/MEMS Technology Applied to Ordnance Inventory (Doerr, Gates, & Mutty, 2005)

This report analyzed the costs and benefits of fielding RFID/MicroElectroMechanical System (MEMS) technology for the management of ordnance inventory. The approach was named hybrid because both qualitative and quantitative methods were used to investigate the cost-benefit of a potential RFID/MEMS implementation.

> The ROI calculation we report is based on the standard formula for the Internal Rate of Return, with changes in expected expenditures, or cash flows, taking the place of revenue – cost. That is, the return on investment will be calculated as the discount rate that makes the net present value (NPV) of cash flow changes equal to zero. (Doerr et al., 2006, p. 8).

$$IRR = i \ni NPV = \sum_{n} \Delta E[cashflows]/i = 0$$

The result of this study using hybrid approach found that:

> Our cost analysis showed that this RFID/MEMS application should produce substantial cost savings, and our sensitivity analysis suggested that these savings were robust against moderate mis-estimates from our subject matter experts (Doerr et al., 2006, p. 33).

Even though the hybrid approach showed the apparent strength of the cost-based analysis in this case, the authors agree with the following statement: “it remains important with RFID to be able to systematically weigh non-cost benefits, and implementation obstacles” (Doerr et al., 2006, p. 34)

In this sense, the KVA approach can provide a systematic means to produce an estimate of non-cost benefits using common units of outputs (Stewart. T.A., 1997, p. 239) as a surrogate for revenue when used in conjunction with the market comparables approach. The authors will apply the KVA methodology to estimate the ROI on two actual implementations of RFID in the MND.

2. The Concurrent Implementation of Radio Frequency Identification and Unique Item Identification at Naval Surface Warfare Center, Crane, IN as a Model for a Navy Supply Chain Application (Obellos, Colleran, & Lookabill, 2007)

The purpose of this project was to identify the typical Navy Supply material operational processes as seen at Naval Surface Warfare Center Crane, IN (NSWC Crane). The study used this information as a basis for identifying the most promising automated information technology for those operational processes. The study also provided an outline for an RFID/UID concurrent implementation plan that best applies to NSWC Crane. It concluded with a Knowledge Value Added (KVA) Return on Investment (ROI) analysis of the RFID/UID implementation plan.

The study concluded that RFID/UID technology implementation would increase the ROI benefit for the inventory management process analyzed by investing in RFID/UID technology. However, unlike the current study, their ROI estimates were based on projected benefits and were not based on actual implementation of the technology in the process. The expected ROIs on the use of RFID/UID for the inventory management process appeared to be somewhat conservative based on a comparison to ROIs from the implementation of the technology in the current study.

3. A Comparable Market Study of RFID for Manual Item-Level Accountability Inventory and Tracking Systems (V. V. Courtney, 2007)

This thesis focused on estimating the ROI for use of RFID technology in item-level tagging of assets. The business model used for this thesis focused on organizations that provide reference material management services (RMMS), e.g., library reference material, employee privacy information records, laptops, etc., to the DoD users. The thesis evaluated the capabilities available in RFID technology that could eliminate the challenges posed by the lack of item visibility that existed in manual RMMS business processes.

This thesis reviewed the experience of companies in the private sector that have reported positive ROIs benefits by implementing RFID for the purpose of asset control/management. The study also projected the potential ROIs from using this technology in the DoD logistic processes. However, it also pointed to potential roadblocks in implementing the technology. “The major obstacle facing an organization desiring to integrate RFID capabilities lies in the initial investment of primary cost drivers such as price per tag and software”(V. V. Courtney, 2007, p. 73). The current research also found that in actual implementations the ROI on use of this technology was sensitive to these costs.

4. Balanced Scorecard (BSC)

At the level of the individual organization, the BSC has been used to measure its own performance. The followings is the basic concept of BSC:

> The BSC measures performance from at least four perspectives: learning and growth, internal process, customers, and financial. Adequate investment in these areas is assumed to be critical for long-term success. Together, these four perspectives attempt to provide a balanced view of the present and future performance of the business (Housel and Bell, 2001, p. 38).

The BSC is the most typical measurement tool in the context of stakeholder theory. BSCs focus on developing and monitoring strategy via a family of measures. They help translate corporate strategy into a set of goals and objectives, and their success

is tracked through multiple performance measurements. As such, BSC aids in communication and in setting strategic objectives (Jensen, 2001).

BSC has been used in the MND to analyze the cost-benefit of RFID. In 2007, the Korea Aerospace University (KAU) suggested the benefit of RFID by using Core-Elective Performance evaluation. Considering the fact that the military is a non-profit organization, the KAU set the core performance index to make up for the traditional performance evaluation's limitations. This new approach classifies the core performance index into four perspectives according to their functional standpoints: i) financial point, ii) system satisfaction point, iii) job-processing point, and iv) renovation and growth point. The specific lists are as follows (K. Y. Jung, 2007):

Table 1. Core performance index (From: K. Y. Jung, 2007, p. 33)

Standpoint	**Core performance index**	
Renovation Growth	Reducing mixed-loading ammo Reducing non-approved bullet loading	System application rate Requirement reflection
Job-Processing	Reducing processing error Increasing storage space utilization	Reducing inventory check error Checking the storage just in time
Financial	Reducing distribution time Reducing administrative tasks	Reducing daily-checking time Reducing inventory-checking time
Customer satisfaction	Sharing information in real time 3D simulation satisfaction	Utilization convenience Education performance satisfaction

> The main purpose of the research was to explore the performance measurement of public project and to show the different degrees of satisfaction on the performance of projects by positions and roles of interviewee, e.g., project managers, project programmers, administrator of organization, and user in their project (K. Y. Jung, 2007, p. 79).

Jung (2007) used a BSC approach to assess surveyees' perception of the improvement resulting from the implementation of RFID in various logistics processes. He found that a significant number of the surveyees believed that the use of RFID technology improved the ammunition distribution process.

In detail, the researcher collected forty copies out of fifty-three surveys from the respondents; of these forty copies, thirty-eight surveys all but two surveys that were not properly answered were analyzed by the Statistical Package for the Social Sciences (SPSS) 12.0 program. He used 'Cronbach Alpha Value' and 'Factor Analysis' to verify the validity and reliability of survey results.

Even though the BSC used by the KAU was modified to be applied to the military environment, this approach still had limitations similar to those of the traditional BSC. "The actual nature of the relationship among the indicators is more a matter of what the individual manager believes, or via a consensus-gaining process, what a group of managers believes about the relationship among the measures" (Housel & Bell, 2001).

> The BSC does not yield a score that would allow us to distinguish winners from losers. For this reason, the system is best described not as a scorecard, but as a dashboard or instrument panel. It can tell managers many interesting things about their business, but it does not give us a score for the organization's performance (Jensen, 2001, p. 19)

> In practice, scorecards typically have about five subscales for each perspective. The scales use ratio, interval, ordinal and nominal approaches to capture data about corporate performance. Resulting scores are normalized to combine them into a single decision point. This approach assumes that the various measures are related to one another in a cause-effect chain linked to corporate strategy and the corporate bottom line. Developing a mathematical algorithm for the various measures within a consistent theoretical framework has proven to be difficult (Housel and Bell, 2001, p. 38).

Table 2 shows 'Balanced Scorecard Perspectives' as mentioned in the previous paragraph.

Table 2. Balanced Scorecard Perspectives (From: Housel and Bell, 2001, p. 38)

Perspective	**Focus**
The Learning and Growth Perspective	Directs attention to the organization's people and infrastructure.
The Internal Perspective	Focuses attention on the performance of the key internal processes that drive the business. Improvement in internal processes now is a key lead indicator of financial success in the future.
The Customer Perspective	Considers the business through the eyes of a customer, so that the organization retains a careful focus on customer needs and satisfaction.
The Financial Perspective	Measures the ultimate results that the business provides to its shareholders.

As previously mentioned, BSC is a managerial tool of stakeholder theory. In stakeholder theory, the notion of a "balanced" scorecard is appealing, but suffers from many flaws. Using multiple survey questions in the BSC to evaluate the performance of a new system or process unit may allow managers' biases to affect the outcomes, and also do not give a relatively objective score for the organization's performance, or for the performance of its business units.

Survey results are widely used to assess performance in the management literature, and self-assessments of performance are commonly accepted surrogates for performance. Also, there are commonly used methods available to assess and correct the sort of bias to

which the authors refer. However, the authors believe the KVA approach, detailed below, is superior because some of the data are market provided. Also an analysis of the data (stakeholder-provided and market-provided) can be accomplished by disinterested investigators such as the authors of this thesis (of course, if the analysis were undertaken by consultants or as a part of a funded research project, the same limitations of bias would apply to the KVA approach).

Finally, when the authors claim the KVA approach is superior, they mean it is superior in terms of outcome, e.g., it will yield better decisions in terms of which technologies (like RFID) to acquire, and which technologies should be bypassed (at least temporarily) or abandoned. In this literature review, the authors have pointed to a number of authors who have used KVA, and who argue for its superiority on the grounds the authors have detailed. But this claim of superiority is an empirical one, and it remains an issue of open debate in the literature. The direct support of this claim of superiority is beyond the scope of this thesis, which will not itself compare approaches, but instead, use the KVA approach as an alternative to the BSC approach already used.

Thus, since BSC lacks a common theoretical framework and unit of analysis, this approach is not an adequate measurement tool to assess IT performance, specifically the knowledge value embedded in assets such as IT systems and humans.

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III. KVA THEORY

A. INTRODUCTION

It is difficult to find a metric that can objectively and accurately measure performance. One common measure that is frequently used is cost and its many variations, but this does not define a value in a non-profit organization such as the MND and the DoD. Another metric is ROI, although it is not easy to assess the ROI on organization assets such as humans and IT systems, due to the difficulty of allocating and quantifying the revenue attributable to those assets. However, KVA provides a framework to estimate the ROI by allocating revenue in common units of output to each process (Housel and Bell, 2001; Seaman, Housel, & Mun, 2008, p. 14).

This project utilizes two previous studies for purposes of comparison. The first is 'The Concurrent Implementation of Radio Frequency Identification and Unique Item Identification at Naval Surface Warfare Center, Crane, IN as a Model for a Navy Supply Chain Application' (Obellos, Colleran and Lookabill, 2007). The second is 'Integrated Portfolio Analysis: Return on Investment and Real Options Analysis of Intelligence Information Systems (Cryptologic Carry On Program)' (Rios, Jr., Housel, and Mun, 2006). The authors referred to the latter report for most of the review of the KVA theory and its application to estimating the ROI on IT. The other project applied the KVA methodology to derive the ROI on IT investments by quantifying the value of RFID/UID technology, specifically the efficiency (productivity) and effectiveness (profitability) created by RFID/UID in the inventory process, which made it directly applicable to this study.

B. RETURN ON INVESTMENT

Large cost increases and extended delivery schedules in the DoD programs caused inaccuracies of 20–50% or higher in estimates of time and money. Consequently, it has been difficult for decades to derive the accurate ROI on the DoD IT development programs. Likewise, large technology projects in the private sector have shown a low

success rate (as shown in Figure 3). The research firm The Standish Group has shown that the chance of failure rate was 68% in the case of IT projects with investment over $3 million (Rios, Housel, & Mun, 2006, p. 3).

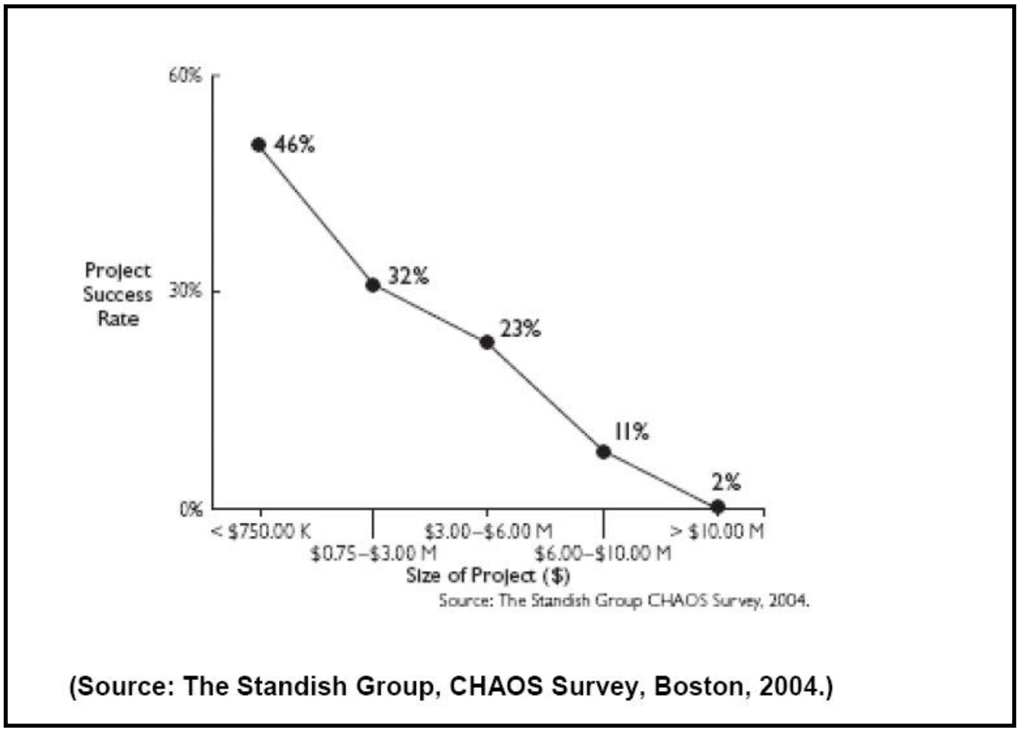


Figure 3. Rate of Successful IT Project Delivery (From: Rios et al., 2006, p. 3)

This high failure rate has forced the private sector to develop accurate metrics to assess the value of IT investments. The corporate-level approaches deal with the value from human and IT systems to the overall performance; the sub-corporate-level approaches try to measure productivity (output-input ratios) on their core processes. The private sector has tried to use traditional financial measures and heuristic methods. The common goal of these methodologies is to provide managers with the value added by IT investments. Table 3 shows the types of metrics used to estimate the value of IT investments (Rios et al., 2006, p. 3).

Table 3. Approaches to Measuring Return on IT (From: Pavlou et al., 2005, p. 203)

Level of Analysis	Approach	Focus/Assumptions	Key Advantages	Limitations
Aggregate Corporate (firm) level	*Process of Elimination (i.e. Knowledge Capital)*	• Treats effect of IT on ROI as a residual after accounting for other capital investments	• Uses commonly accepted financial analysis techniques and existing accounting data	• Cannot drill down to effects of specific IT initiatives • ROI on IT difficult to measure directly
	Production Theory	• Determines IT effects through input output analysis using regression modeling techniques • Economic production function links IT investment input to productivity output	• Uses econometric analysis on large data sets to show contributions of IT	• "Black-box" approach with no intermediate mapping of IT's contributions to outputs
	Resource-Based View	• Links firm's core capabilities with competitiveness • Uniqueness of IT resource = competitive advantage	• Uses strategic advantage approach to IT impacts	• Causal mapping between IT investment and firm competitive advantage difficult to establish
Corporate/ sub-corporate	*Option Pricing Model*	• Determines best point to exercise an option to invest in IT • Timing exercise option = value	• Predicts future value of IT investment	• No surrogate for revenue at sub-corporate level
Sub-corporate (Process) level	*Family of Measures (i.e. Balanced Scorecard)*	• Measures multiple indicators to derive unique contributions of IT	• Captures complexity of corporate performance	• No common unit of analysis/ theoretical framework • Multiple indicators required to measure performance
	Cost-Based (i.e. Activity-Based Costing)	• Uses cost to determine value of IT • Derivations of cost ≈ value	• Captures accurate cost of IT	• No surrogate for revenue at this level; no ratio analysis
	Knowledge Value Added (i.e. KVA)	• Allocates revenue to IT proportionate to contributions to process outputs • IT contributions to output ≈ IT value-added	• Allocates revenue and cost of IT allowing ratio analysis of IT value-added	• Not directly applicable to highly creative processes

Most ROI metrics focus on corporate-level financial returns, which cannot be applied to estimate the value of IT investments of the MND and the DoD. From the perspective of the military, the overall operational readiness cannot be measured in terms of revenue. Instead, this project will use the KVA theory as an alternative to identify and quantify the value by implementing the RFID system (Obellos et al., 2007, p. 79).

The KVA theory has been used in many areas in the private and public sectors. For example, Courthouse Athletic Club was saved from bankruptcy and secured market share by virtue of a KVA analysis (Housel & Bell, 2001, p. 106). For the past several years, research on measuring the ROI on IT systems using the KVA methodology has been performed at the Naval Postgraduate School (NPS). Hence, it would be beneficial to introduce and explain the concept and steps to apply the KVA to other organizations such as the MND, which has not yet used it.

C. KVA THEORY OVERVIEW

Housel and Bell (2001, p. 110) defined *knowledge* as "something that enables a person or machine to solve problems of a certain type" For instance, "a set of logical rules or a computer program that can be used to solve the problem is *knowledge*"; in the case of people, they can have knowledge, but they are a *knowledge source* rather than knowledge itself.

> The Knowledge Value Added (KVA) methodology was created by Dr. Thomas Housel and Valery Kanevsky and has been published internationally in numerous articles and books about knowledge management and business process reengineering (Housel & Kanevsky, 1994; Kanevesky & Housel, 1997)

The KVA theory provides a metric to objectively estimate value and allocate revenue to all organizational assets including tangible resources, e.g., material, supplies and equipment, and intangible resources, e.g., human capital, IT system, and organizational process (Pringle & VanOrden, 2009, p. 7).

1. Fundamental Assumptions of KVA

The KVA assumes that if an organization has the knowledge necessary to make a change in a process, then it can produce a change by virtue of the knowledge. The underlying assumptions are shown in Figure 4. "By definition, if we have not captured the knowledge required to make the changes necessary, we will not be able to produce the output as determined by the process" (Housel & Bell, 2001, p. 94).

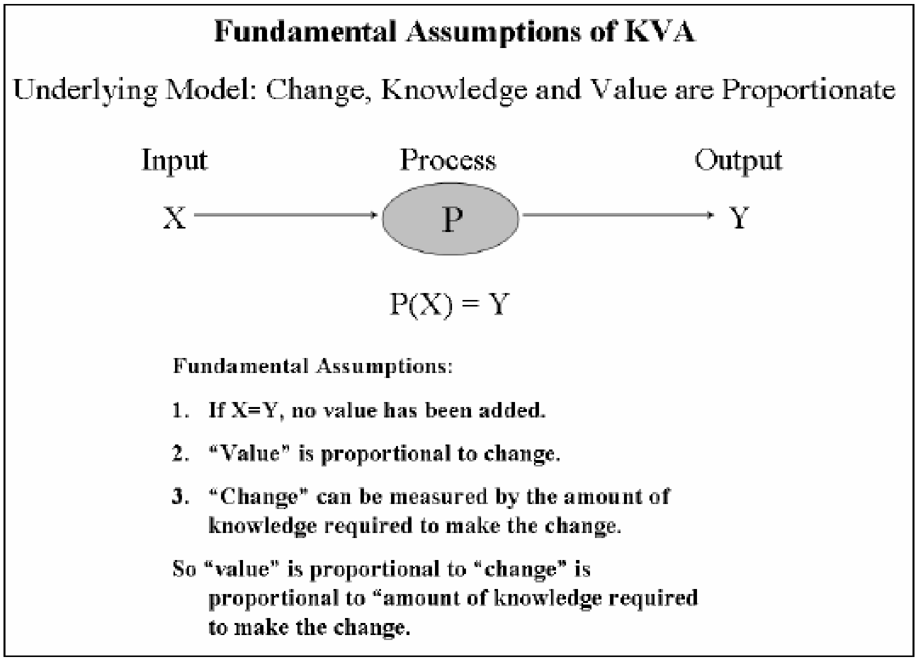


Figure 4. Fundamental Assumption of KVA (From: IS 4220-Business Process Reengineering with IT)

2. KVA Methodology

According to the KVA theory, there are several different approaches to measure the value of knowledge resident in the core processes; the knowledge within a process can be embodied as learning time, process instructions, decision points, line of code, information theory '(bits)' and entries on a sales order form. Table 4 shows three approaches to the KVA (Housel & Bell, 2001, p. 95).

Table 4. Three Approaches to KVA

Steps	Learning time	Process description	Binary query method
1	Identify core process and its sub-processes.		
2	Establish common units to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description.	Create a set of binary yes/no questions such that all possible outputs are represented as a sequence of yes/no answers.
3	Calculate learning time to execute each sub-process.	Calculate number of process instructions pertaining to each sub-process.	Calculate length of sequence of yes/no answers for each sub-process.
4	Designate sampling time period long enough to capture a representative sample of the core process's final product/service output.		
5	Multiply the learning time for each sub-process by the number of times the sub-process executes during sample period.	Multiply the number of process instructions used to describe each sub-process by the number of times the sub-process executes during sample period.	Multiply the length of the yes/no string for each sub-process by the number of times this sub-process executes during sample period.
6	Allocate revenue to sub-processes in proportion to the quantities generated by step 5 and calculate costs for each sub-process.		
7	Calculate ROK, and interpret the results.		

This study will choose learning time as a representation of knowledge. In this case, learning time can be defined as the amount of time to study the know-how necessary to make process outputs. Learning time provides a quick and convenient way to estimate the amount of knowledge in a certain process (Housel, 2009).

The process required to implement the KVA methodology is summarized in Table 5 (Rios, Housel, & Mun, 2006, p. 8).

Table 5. NPS valuation Framework

Data Collection	KVA Methodology
• Collect baseline data • Identify sub-process • Research market comparable data • Conduct market analysis • Determine key metrics	**Step 1:** Calculate time to learn. **Step 2:** Calculate value of Output (K) for each sub-process **Step 3:** Calculate Total K for process **Step 4:** Derive Proxy Revenue Stream (when desired) **Step 5:** Develop the Value Equation Numerator by assigning revenue streams to sub-processes **Step 6:** Develop value equation denominator by assigning cost to sub-process **Step 7, 8, 9:** Calculate metrics: Return on Investment (ROI) Return on Knowledge Assets (ROKA) Return on Knowledge Investments (ROKI)

The first step is to collect the data on identified processes and sub-processes necessary to produce an output. Comparing cost and revenue data through market research with other organization with similar processes extends this step to establish baseline information. Then, the estimation on value and cost can be performed by the KVA methodology. The final step is to analyze the ROI using the data from cost-per-unit and price-per-unit estimates (Rios et al., 2006, p. 8).

By finding the value of knowledge resident in an organization's core process, employees and IT, the KVA identifies the actual cost and revenue of a process output. According to Rios, Housel and Mun (2006, p. 8), the KVA can calculate unit costs and unit prices of products and services since it identifies every process necessary to make an output and the historical costs and revenues; an output can be a product or service as the end result of an organization's operations, as shown in Figure 5 (Rios et al., 2006, p. 8).

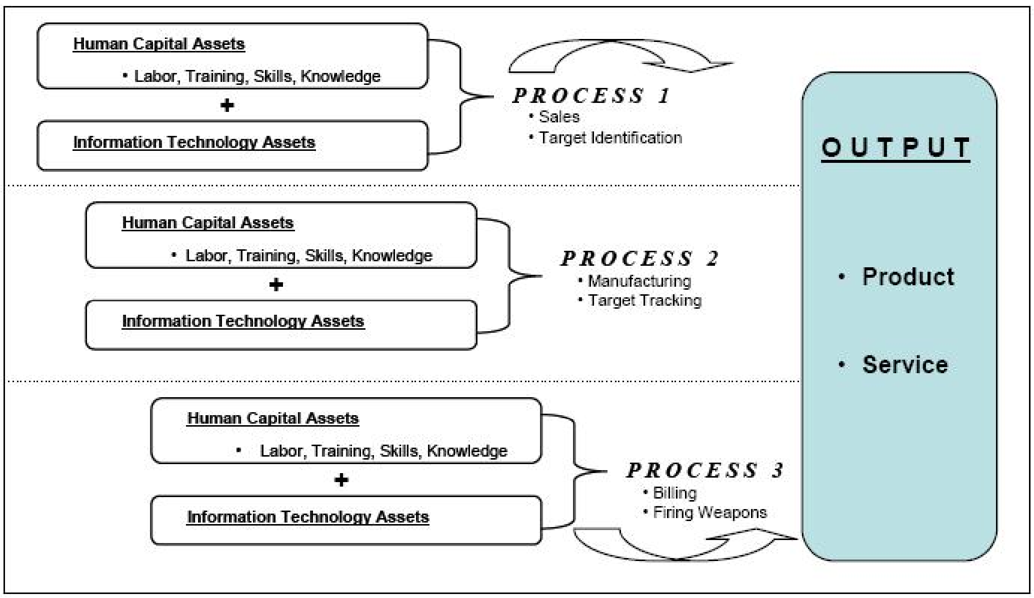


Figure 5. Measuring Output

As a performance measurement tool, the methodology has been used by the DoD and can be used by the MND, as well (Rios et al., 2006, p. 10):

- Compare all processes in terms of relative productivity
- Allocate revenues to common units of output
- Measure value added by IT by the outputs it produces
- Relate outputs to cost of producing those outputs in common units
- Provide common unit measures for organizational productivity

Furthermore, based on the tenets of complexity theory, the KVA assumes that humans and technology in organizations add value by taking inputs and changing them (measured in units of change or complexity) into outputs through core processes. The amount of change an asset produces within a process can be a measure of value or benefit. Additional assumptions are as follows (Rios et al., 2006, p. 10):

- Describing all process outputs in common units (e.g., the time it takes to learn to produce the required outputs) allows historical revenue and cost data to be assigned to those processes at any given point in time.
- All outputs can be described in terms of the time required to learn how to produce them.
- Learning Time, a surrogate for the knowledge required to produce process outputs, is measured in common units of time. Consequently, Units of Learning Time = Common Units of Output (K).
- Common units of output make it possible to compare all outputs in terms of cost-per-unit as well as price-per-unit, because revenue can now be assigned at the sub-organizational level.
- Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied.

Non-profit organizations such as the DoD and the MND can generate market comparable data by describing processes in common units and comparing these to the common units of output in profit making companies. “Market comparable data from the commercial sector can be used to estimate price per common unit, allowing for revenue estimates of process outputs for non-profits. This also provides a common-units basis to define benefit streams regardless of process analyzed” (Rios et al., 2006, p. 10). The KVA is different from the other ROI models since it allows for revenue estimates enabling use of traditional accounting, financial performance and profitability measures. Table 6 provides comparison between traditional accounting and the KVA process costing; the former shows what was spent per category and the latter shows how it was

spent per process (Rios et al., 2006, p. 11). Figure 6 "provides a comparison of traditional corporate level revenue information while the KVA provides this kind of information at the sub-corporate level by taking the corporate level revenue and allocating it to sub-corporate process outputs" (Rios et al., 2006, p. 12).

Table 6. Comparison of Traditional Accounting versus Process Based Costing

	Traditional Accounting		KVA Process Costing		
Explains what was spent	Compensation	$5,000	Review Task	$1,000	*Explains how it was spent*
	Benefits/OT	1,000	Determine Op	1,000	
	Supplies/Materials	2,000	Input Search Function	2,500	
	Rent/Leases	1,000	Search/Collection	1,000	
	Depreciation	1,500	Target Data Acq	1,000	
	Admin. And Other	900	Target Data Processing	2,000	
	Total	**$11,400**	Format Report	600	
			Quality Control Report	700	
			Transmit Report	1,600	
			Total	**$11,400**	

Traditional Accounting/ Finance Measure	KVA Process Value Measure
Sales/Revenues	Common units of output
Product price	Market comparables: Price-per-unit of output
Total Revenues	Total units of output X price-per-unit = total revenue surrogate

Figure 6. Comparison of Outputs Traditional Accounting Benefits (Revenues) versus Processes Based Value

Processes in the KVA can be ranked depending on the degree to which they add value to the organization or its processes. It enables decision makers to identify which processes add value—those that will most likely contribute to accomplishing the mission, delivering a service, or meeting customer demand.

IV. CASE STUDIES (PROOFS OF CONCEPT)

As stated before, RFID was used to improve the ammunition distribution process approximately five years ago. In particular, RFID was implemented by the Army for ammunition management and by the Air Force for F-15K parts management. This paper tries to demonstrate how the KVA can be used to estimate the ROI on implemented RFID systems these two cases. From the KVA results, the authors verified the change in the ROI and the ROK before and after RFID implementation.

Again, the ROK is an estimate of the value or benefit over cost ratio for each sub-process in the ammunition distribution process and F-15K parts management process. The ROK % shows which of these processes add the most and least value to the overall distribution process and inventory management system, so that changes can be made to improve the process. For the convenience of readers, the ROI can be calculated by subtracting 100% from the ROK.

Ultimately, the ratio of values from analyzing the data through the KVA will provide a new source of productivity information to decision makers before making an IT acquisition. Implementing a KVA methodology will create a new process performance metric that can be collected on a routine basis. These performance metrics provide the kinds of system performance information they need to make technology investment decision.

A. AMMUNITION STORAGE WAREHOUSE (ASW) & 40TH SUPPLY DEPOT

1. Process Description and Modeling

a. ASW

Before implementing RFID, the MND had used the software program AIS to optimize the process of requirement and distribution of ammunition. This program saved a great amount of time as well as improving job efficiency. However, it also consumed considerable time in managing the warehouse and checking ammunition loaded on trucks each time. For these reasons, more employees and time were required

for the ammunition distribution process. With the RFID implementation, waiting time was reduced and redundant processes were eliminated. The eleven sub-processes of distribution of ammunition were diminished to nine sub-processes.

The next eleven processes were used for describing the baseline ammunition distribution process. Figure 7 depicts the 'Before RFID' process. As stated before, paperwork for ammunition requirement and approval is done through AIS (J. H. Lee, 2005, p. 46).

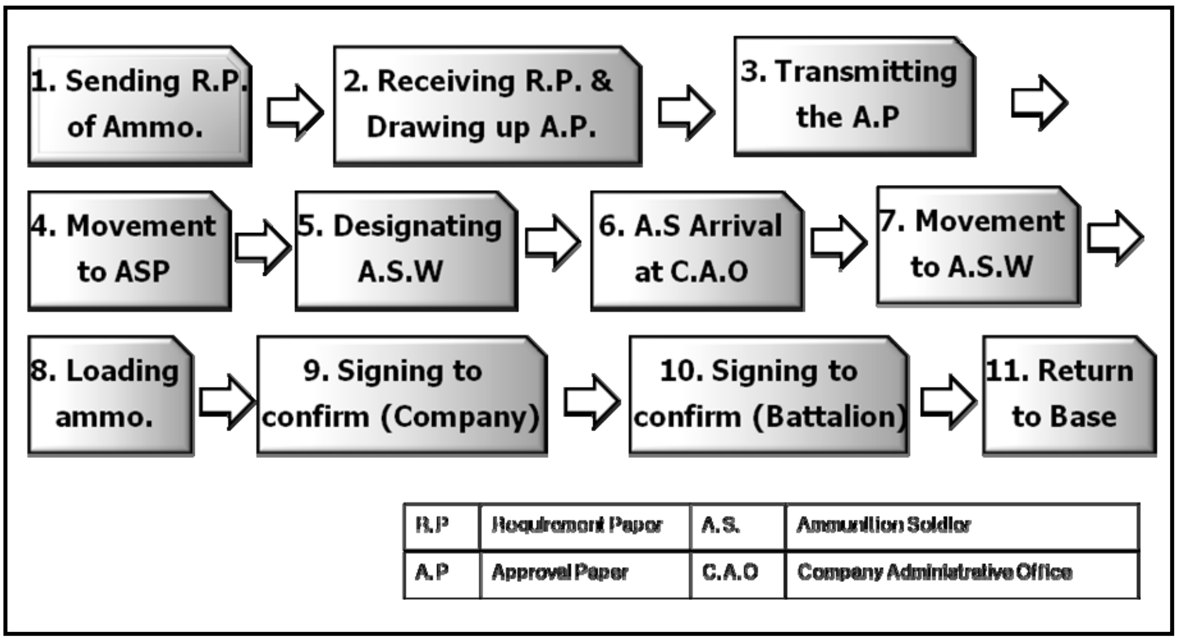


Figure 7. Ammunition Distribution Process (Before RFID)

Figure 8 represents the distribution process after RFID. The process is reduced to nine processes due to RFID. The workers in the process share the information automatically through the tags attached on the boxes and bullets. The users do not have to do the redundant work such as 'Signing to confirm (Company).' The 'Signing to confirm (Company)' process is a redundant work, similar to the 'Signing to confirm (Battalion)' process. Normally, this administrative process requires much time to complete because of the waiting time. The authors verified the significant time saved

from the technology. In the private sector, this time saving can lead to increased profits; in the public organization, it can greatly improve mission accomplishment.

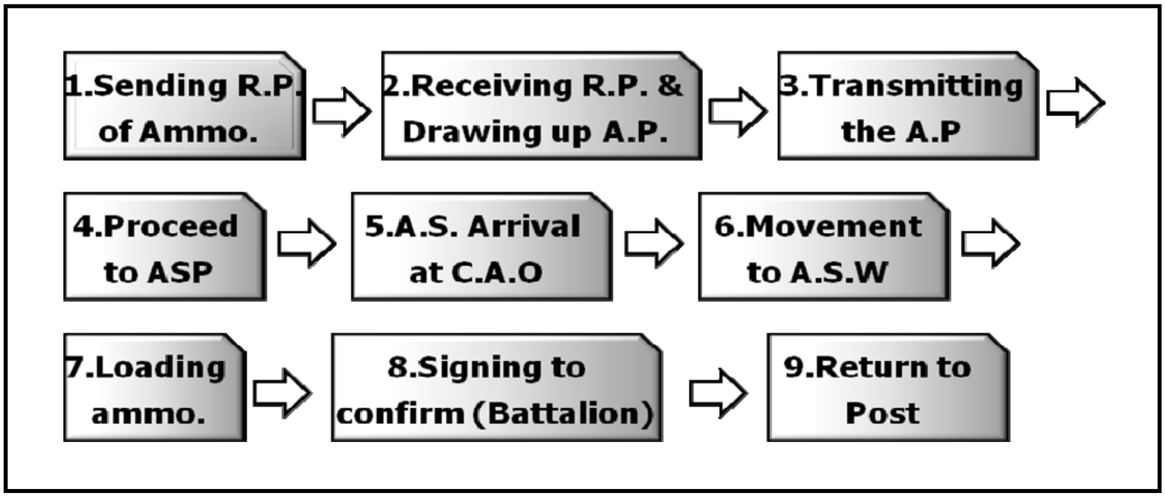


Figure 8. Ammunition Distribution Process After RFID (From: J. H. Lee, 2005. p. 46)

Table 7 is a brief description of the generalized process for this model. The bold characters represent the eliminated processes before and after RFID.

Table 7. Sub-Process Description

Sub – Process Name	Sub-Process Description
1. Sending Requirement Paper (R.P.) for Ammo	The combat units require Ammunition Supply Post (ASP) to provide ammunition by sending R.P through AIS. The time for this job is assumed to be 30 minutes including the administrative time. However, this time can vary depending on the delay time consumed by the senior officers who are responsible for signing documents.
2. Receiving R.P. & Drawing up A.P. (Approving Paper)	ASP receives the R.P through AIS from the combat units which required ammunition. Next, the administrative soldier draws up the A.P. The A.P will be transmitted to the senior officer through AIS. This time depends on the waiting time by the senior officer. In this paper, this process time is assumed to be 30 minutes.

Sub – Process Name	Sub-Process Description
3. Transmitting the A.P through AIS	After getting approval from the senior officer, the A.P is sent to the combat units that requested ammunition.
4. Proceed to ASP	The units that demanded ammunition proceed to ASP holding the A.P. Distance is assumed to be 3 or 5 miles between the combat unit and ASP. Movement speed is authorized as approximately 37 mile per hour. After passing through ASP gate, the warrant officer of the combat unit goes to the administrative office in the battalion to verify A.P and to learn which warehouse is available. The administrative soldier informs the warrant officer of the correct warehouse.
5. Designating A.S.W	If the warehouse is set, the warrant officer goes to the administrative office of the company in charge of the designated warehouse. This company designates the Ammunition Soldier (A.S) who helps with loading and checking the ammunition. This process will be removed after RFID implementation due to the information about warehouse provided by RFID technology.
6. A.S. Arrival at Company administrative office	The designated A.S. comes to the administrative office.
7. Movement to A.S.W	Truck for loading ammunition goes to the A.S.W with A.S.
8. Loading ammo	The warrant officer loads the ammunition with the other soldiers. The A.S checks the whole process and the items such as right amount of ammunition and appropriate types of ammunition. This process is done manually by the A.S in the "Before RFID" process.
9. Signing to confirm (Company)	The warrant officer goes to the company to get confirmation for ammunition loading and to sign the paper in the administrative office. This process is executed right before going to battalion. This job will be eliminated after RFID implementation due to real data share with battalion.
10. Signing to confirm (Battalion)	The warrant officer goes to the battalion to do exact same work in the company.

Sub – Process Name	Sub-Process Description
11. Return to Post	The combat units loading the required ammunition return to post.

b. 40th Supply Depot

The 40th Supply Depot was selected for the purpose of this study, which had the project name of 'Trial infrastructure of F-15K (new weapon) parts management system using RFID.' The project period covers six months and the Depot has entered a stable state after five years of using RFID technology. The processes of the management system consist of receiving, warehousing, taking goods from the warehouse, and transportation. The system in use is composed of the server operating database, control system managing and controlling RFID, portable reader, fixed reader and reader for container, wireless Access Point (AP), and tag producer. Figure 9 shows the overall RFID system structure.

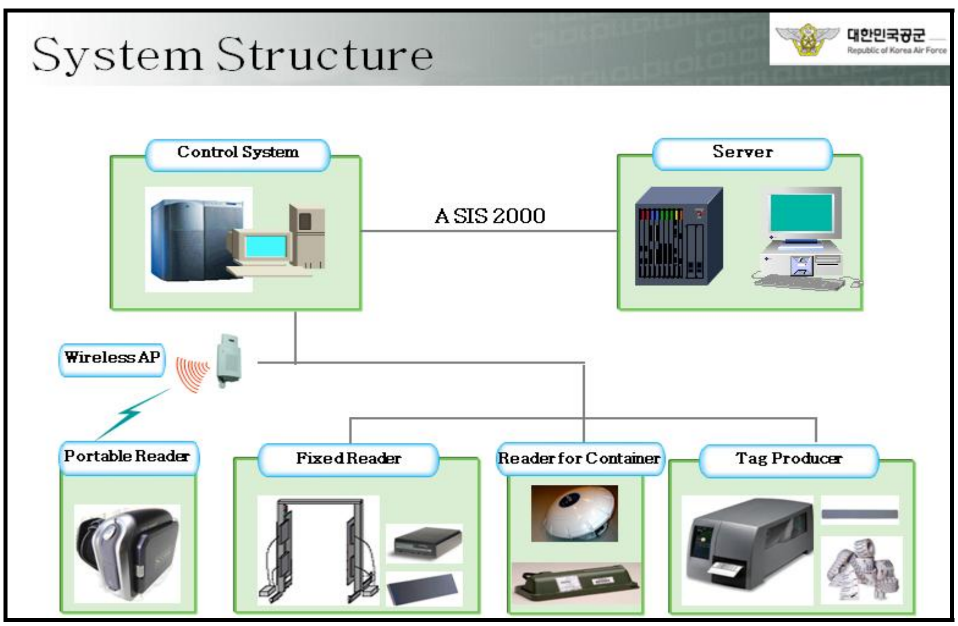


Figure 9. System structure (From: Report of KIDA IT Consulting Group)

With the help of the system, the 40th Supply Depot can do the auto-recognition for the shipping of containers, estimating storage space, conducting inventory,

and acquiring resources management information. Figure 10 illustrates the hardware structure of the 40th Supply Depot to automate the processes.

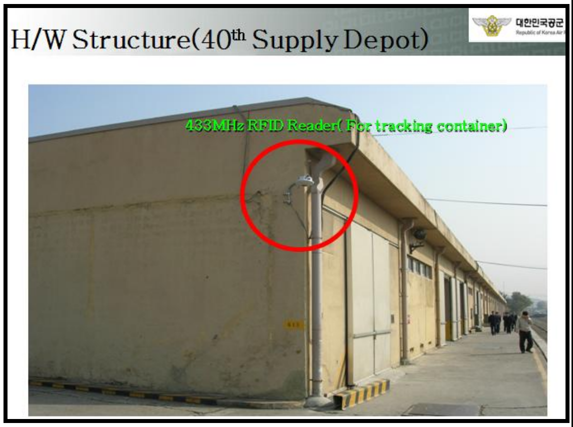
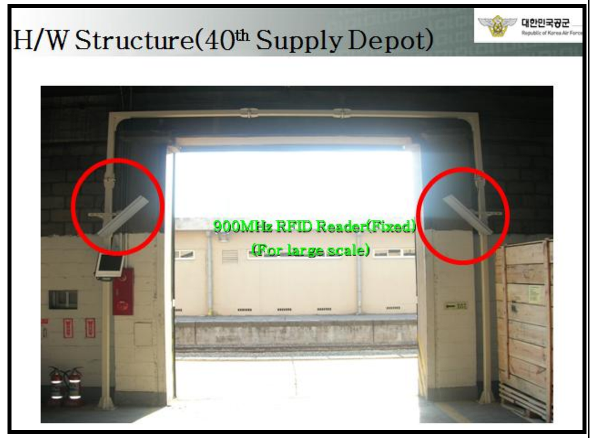
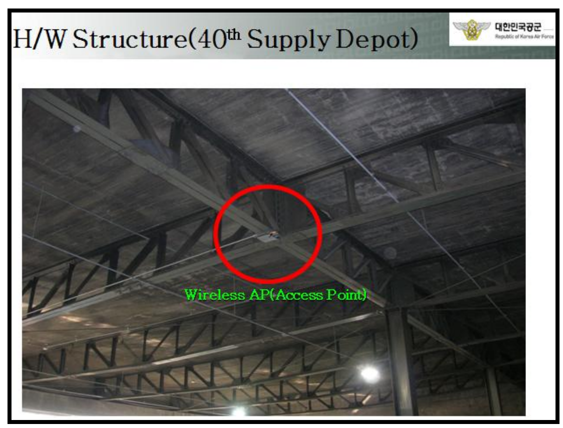
	
Reader for Tracking Container	Fixed Reader for Large Scale Items
	
Fixed Reader for Med/Small Items	Wireless AP

Figure 10. Hardware Structure (From: Report of KIDA IT Consulting Group)

The authors will limit the KVA analysis to the inventory checking process due to the difficulty of collecting necessary data pertaining to all processes that the 40th Supply Depot implements using RFID. Although this is a substantial limitation compared to our initial goal of analyzing the ROI for the entire implementation, it is necessary to limit the scope of the investigation because of the availability of the authors' time in

working on this thesis and for the purpose of comparing to the same sub-process in the 'RFID/UID' case study (Obellos et al., 2007). The authors will return to this limitation in the Conclusions, but here note that the limitation is in keeping with their primary goal of providing a proof-of-concept for the KVA approach. Before implementation of RFID, the Depot checked the inventory through ten processes. After implementation of RFID, the necessary processes were reduced to six. Figure 11 shows the processes to be modeled before implementing RFID in the Depot.

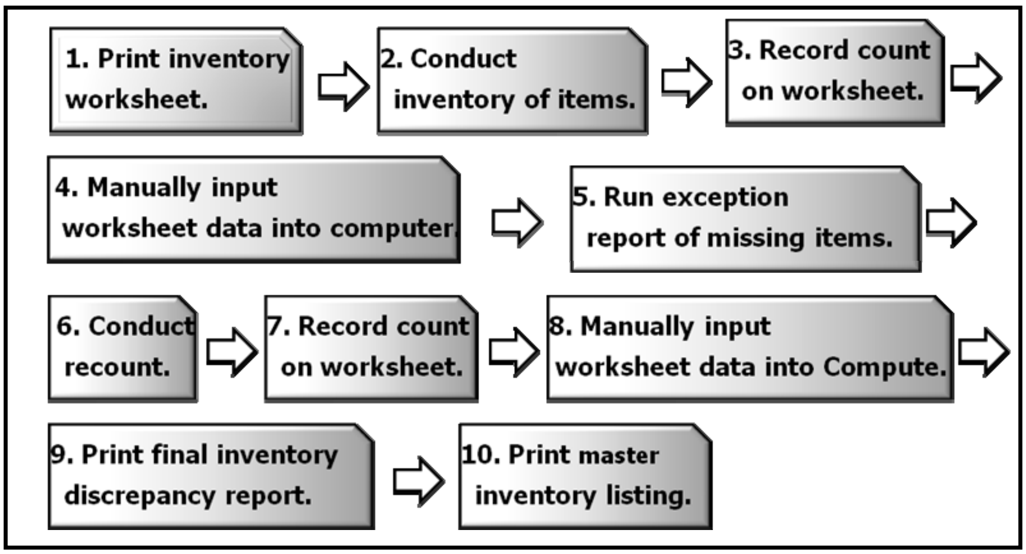


Figure 11. Inventory checking processes before RFID
(From: Survey results from the 40th Supply Depot)

With the help of RFID, three processes were merged into one process; the second, third, and fourth processes of 'Before RFID' were consolidated to become the second process of 'After RFID' and the sixth, seventh, and eighth processes of 'Before RFID' were integrated as the fourth process of 'After RFID.' Currently, the inventory checking process is performed through six processes. Figure 12 depicts the inventory checking processes of 'After implementation of RFID.'

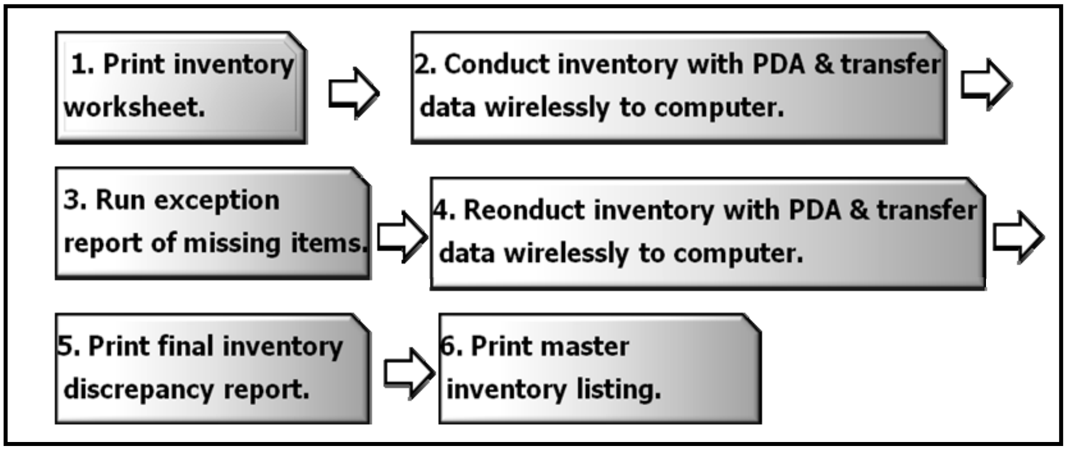


Figure 12. Inventory checking processes after RFID (From: Survey results from the 40th Supply Depot).

In the case of the 40th Supply Depot, this consolidation resulted in labor savings of 38 soldiers and streamlined the inventory checking processes with the help of RFID. Figure 13 demonstrates how the employee conducts inventory with Personal Digital Assistants (PDA).

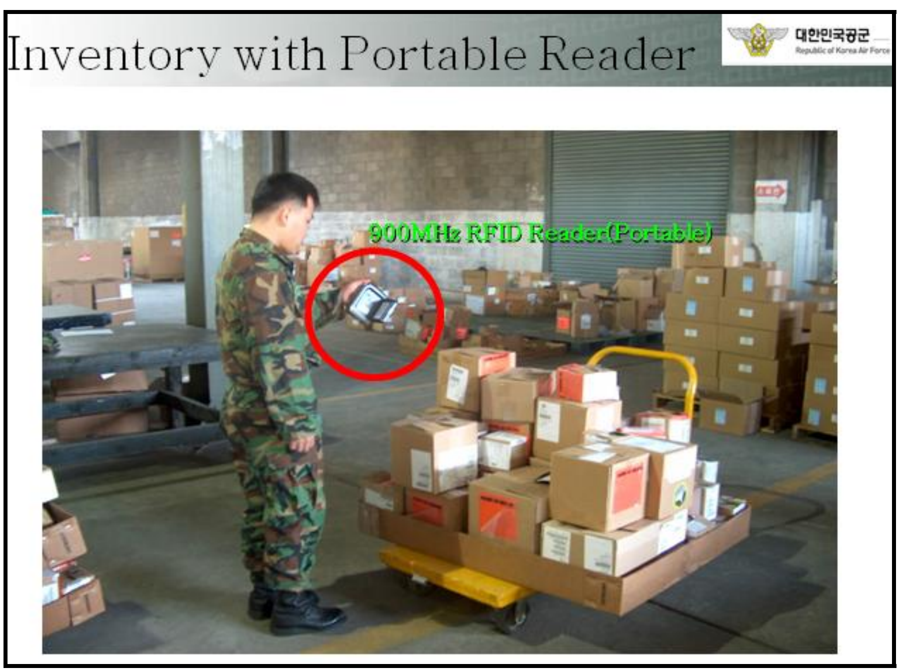


Figure 13. Inventory with PDA

2. Data and Assumptions

The following data and assumptions will be applied to the ammunition distribution model and the inventory process of the 40^{th} Supply Depot model.

a. Data

- **Number of Employees**

The 'Number of Employees' column indicates the number of personnel involved in the specific sub-process. The number of personnel participating in each process is based on the normal process of ammunition distribution and inventory checking including enlisted men, sergeants and officers within the process.

- **Rank Order of Difficulty**

All the processes are ranked in order of difficulty to learn, where 1 = easiest and n = hardest. This order is ranked intuitively by the top manager according to the complexity of learning each process. The complexity of the processes is also indicated by the relative learning time column, where the most complex tasks are presumed to take longer to learn.

- **Relative Learning Time (RLT)**

The RLT is derived from the relative distribution of 100 available units of time (or days, weeks, etc.) or hours in this case for the average person to learn how to perform each of the processes, including learning to manually perform what is currently automated.

- **Actual Average Learning Time (ALT)**

The actual learning time (hours, days, weeks, etc.) is what it would take to train the beginner to perform each of the processes to the degree of a skilled person. This learning time is used for calculating the value of knowledge made in each process.

- **Correlation**

The accuracy of data given for 'Rank Order of Difficulty,' 'Relative Learning Time,' and 'Actual Average Learning Time' is verified by testing the

correlation among the three. If the correlation is equal or more than 0.85, the data is assumed to be reliable; especially, the correlation between ‘Relative Learning Time’ and ‘Actual Average Learning Time’ is more important since these are more granular estimates.

Table 8. Correlation in ASW and the 40th Supply Depot

Correlation	ASW		40th Supply Depot	
	Before RFID	After RFID	Before RFID	After RFID
Rank Order of Difficulty vs. RLT	84%	75%	82%	78%
RLT vs. ALT	96%	76%	88%	97%

- **Percentage Automation**

This is a representation of the extent to which automation is utilized in the sub-process. Automation is measured on a scale from 0-100%. Also, the Percentage Automation column represents how IT is used to complete the process, hardware and software IT designed and implemented for the purpose of enabling distribution processes. The degree of automation in the sub-process is considered the amount of activity that is carried out completely by IT resources.

- **Times Performed in a Year**

The times performed in a year category represent the number of times each sub-process is executed by the specified personnel and systems for that sub-process.

‘Times performed in a year’ of ‘After RFID’ was calculated from the ratio of time to completion between ‘Before RFID’ and ‘After RFID.’ The ratio is two times in the ASW case and 1.41 times in the 40th Supply Depot case study.

- **Average Time to Complete**

The average time to complete is an estimate of the average time needed for a person in each process to complete each task. This data feeds the cost estimate.

- **Automation Tools**

Automation tools means the automation method embedded in the process such as computer program and IT. The MND has used the Defense Information System (DIS) since 1995 to request supplies. The automation tools aid in the completion of each process.

- **Knowledge(Learning Time) Per Process**

(Knowledge/process = Human Learning Time + Human Learning time*% Automation)

Learning Time (Knowledge) was calculated based on the ratio of Human and IT. Fore example, an employee needs 1.5 hour to learn to perform a process with 50% automation. The calculation should be '1.5hours + 1.5hours*50% = 2.25hour' since he, theoretically, has to learn how to do the work in place of IT if the IT system goes down.

- **Total Knowledge(Learning Time)/Year**

(Total Knowledge = Learning time * Times performed in a Year)

Total knowledge represents the amount of knowledge embedded in the sub-process. It is determined by multiplying the total learning time by the number of times performed in a year when a market comparable estimate is approximated, it is possible to get the price per common unit of learning time (i.e., output).

- **Return On Knowledge (ROK)**

The aggregate ROK is the ratio between the total revenue and the total cost for the process. This ratio allows for comparison of expenses and revenues associated with the embedded knowledge assets. This ROK will be used to compare efficiency in performance among sub-processes and thusly assist in determination of relative value.

The numbers in the ROK column can be used as the reference in determining which sub-processes are providing the least or the most amount of value in the overall process. This result gives an insight on how to choose among the following options: deleting them, merging them, increasing IT usage, increasing the number of iterations, or increasing their value by making them more efficient.

b. Assumptions

- **Market Comparable Approach**

The authors will use 'Market Comparable approach' since the MND is a non-profit organization. In terms of the ROI, the MND does not have a definite revenue indicator whereas private sector does. Furthermore, while the overall functions of the MND may not have market forces compared to the private sector, organization have similar core processes that produce comparable outputs. This allowed the authors to use the market comparable labor costs for estimating the revenue produced in the MND (Housel, Rodgers, Tarantino, and Little, 2007). Because the price per unit, at a given market comparable rate, is a constant, revenue is directly proportionate to amount of outputs. This makes the impact of biases in market comparable estimates irrelevant to the resulting relative values of the ROI ratios.

- **Market Comparable Revenue**

The authors use the current military wage as the base to produce 'Market Comparable Revenue'; the authors multiply the military wage for enlisted men by 7 and the others by 1.5. Table 9 depicts the current military wage in the MND (the MND military personnel salary, 2007).

Table 9. Military Labor Cost

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Market Comparable ($)	Market comparable/hr ($)
E	$3,000	$1.44	$ 21,000.00	$10.10
S 1	$15,640	$7.52	$ 23,460.00	$11.28
S 2	$26,490	$12.74	$ 39,735.00	$19.10
S 3	$37,695	$18.12	$ 56,542.50	$27.18
S 4	$49,422	$23.76	$ 74,133.00	$35.64
WO	$49,992	$24.03	$ 74,988.00	$36.05
O 1	$18,984	$9.13	$ 28,476.00	$13.69
O 2	$20,683	$9.94	$ 31,024.50	$14.92
O 3	$30,000	$14.42	$ 45,000.00	$21.63
Assumption : Hourly wage = Base Pay /(260 working days in a year * 8 working hours per day)				

Hence, 'Market Comparable Revenue Per Year' will be 'Market Comparable Revenue Per Hour' times 'Times Performed in a Year.'

- **Market Comparable Labor Rate**

The authors derived the 'Market Comparable Revenue' based on what the market would pay civilians producing the same output. As such, the authors multiplied by 7 for the enlisted men and by 1.5 for the officers to compensate for the civilian wage gap. Table 9 shows the calculation used in the model. This data was aggregated to get the total revenue surrogate estimate and then allocated to the common units of output.

- **Times Performed in a Year**

The authors assume that 'Times Performed In a Year' in ASW for 'After RFID' is twice that of 'Before RFID' under the calculation that 'Average Time to Complete' in entire process of 'After RFID' decreased two times more than that of 'Before RFID.' In the case of the 40th Supply Depot, the 'Times Performed In a Year' is 1.46 times more than that of 'Before RFID.' In both cases, the authors applied the multiplier to the 'Times Performed In a Year' of 'After RFID' conservatively due to the

specialty of the Military circumstance: how much service the military provides. In that case, there are no requirements other than doubled demand.

3. Input Data Analysis

a. ASW KVA analysis

Even before RF-AIS, the ASP of MND had used AIS for ammunition distribution process. Due to this electronic procedure, the working efficiency was higher than manual work.

However, there are still several redundant sub-processes that reduced potential efficiency. RFID was used in an attempt to get rid of these redundancies and other inefficiencies. After RFID implementation, both the ROK and ROI were highly increased by the new system.

The major change is the introduction of RFID technology. Even though not all sub-processes would be affected by RFID technology, the ROK of IT of most of the sub-processes increased and the output noticeably increased, as the value in Table 11 shows. Two sub-processes were eliminated by RFID implementation due to immediacy of the real time information sharing. Table 10 shows the ROK and ROI of IT.

Table 10. Comparison ROK of IT in Each Process

Process		Before RFID		After RFID	
		IT		IT	
		ROK	ROI	ROK	ROI
1. Sending Requirement Paper (R.P.) of Ammo.		484%	384%	1128%	1028%
2. Receiving R.P. & Drawing up A.P.(Approving Paper)		906%	806%	2114%	2014%
3. Transmitting the A.P through wireless system		279%	179%	651%	551%
4. Proceed to ASP		1%	-99%	2%	-98%
5. Designating & A.S Arrival	**Designating ASW**	93%	-7%	N/A	N/A
	A.S Arrival	0%	0%	90%	-10%
6. Movement to A.S.W		0%	0%	0%	0%
7. Loading ammo.		0%	0%	102%	2%
8. Confirm	**Signing to confirm (Company)**	46%	-54%	N/A	N/A
	Signing to confirm (Battalion)	102%	2%	1054%	954%
9. Return to Base		0%	0%	0%	0%
Total		160%	60%	339%	239%

The additional automation of the ‘Loading ammo’ sub-process had a major positive impact on both the ROK and ROI of most of sub-processes. RFID technology eliminated the two processes: ‘Designating ASW’ and ‘Signing to confirm (Company)’ sub-processes.

Especially, the authors tried to focus on the difference of IT ROI between ‘Before RFID’ and ‘After RFID’ to confirm the positive effect of RFID implementation. As shown in the above table, the difference of the ROI about IT was more than doubled on average.

Especially, in the ‘Signing to confirm (Battalion)’ process, the ROI soared from 2% to 954%. This means that this process benefited remarkably from the RFID implementation. Also, this result can be explained by the very large revenue increase produced by RFID technology regardless of the additional cost of the RFID technology.

Furthermore, the 'Signing to confirm (Company)' sub-process was consolidated into 'Signing to confirm (Battalion)' sub-process. This consolidation reduced the workforce and increased the productivity.

Table 11 shows the total ROK and ROI including human revenue and cost. This table also gives information about relationship between revenue and cost as well as about influence of revenue and cost on the ROI.

Table 11. Comparison Total ROK (Human & IT)

Process		Total (Human & IT)							
		Before RFID				After RFID			
		Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Sending Requirement Paper (R.P.) of Ammo.		$ 241,801	$ 22,040	1097%	997%	$ 548,095	$ 30,747	1783%	1683%
2. Receiving R.P. & Drawing up A.P.		$ 453,012	$ 23,857	1899%	1799%	$ 1,026,849	$ 34,381	2987%	2887%
3. Transmitting the A.P through wireless system		$ 139,552	$ 17,985	776%	676%	$ 316,331	$ 22,636	1397%	1297%
4. Proceed to ASP		$ 5,039	$ 100,310	5%	-95%	$ 10,079	$ 100,620	10%	-90%
5. Designating & A.S Arrival	**Designating ASW**	$ 46,310	$ 20,526	226%	126%	N/A	N/A	N/A	N/A
	A.S Arrival	$ 424	$ 254	167%	67%	$ 43,693	$ 20,136	217%	117%
6. Movement to ASW		$ 10,305	$ 2,061	500%	400%	$ 20,611	$ 1,099	1875%	1775%
7. Loading ammo.		$ 88,885	$ 16,666	533%	433%	$ 319,988	$ 157,921	203%	103%
8. Confirm	**Signing to confirm (Com.)**	$ 23,155	$ 18,210	127%	27%	N/A	N/A	N/A	N/A
	Signing to confirm (Bat.)	$ 51,244	$ 18,944	270%	170%	$ 511,921	$ 23,872	2144%	2044%
9. Return to Base		$ 3,876	$ 1,938	200%	100%	$ 7,753	$ 3,876	200%	100%
Total		$1,063,604	$ 242,792	438%	338%	$ 2,805,319	$ 395,288	710%	610%

After implementation of RFID, the ROK and ROI of most sub-processes increased on average two times higher than 'Before RFID.'

In contrast, the ROI of the 'Loading ammo' sub-process is lower compared to the other sub-processes. It seems that the IT had a negative effect on this sub-process because of its high cost relative to the prior approach.

However, the other factor that is also one of the numerators—revenue—should be explored. It is important to note that the amount of output increased enormously. The output from RFID is four times higher than before; the revenue of ‘Before RFID’ is $88,885 versus the revenue of $319,988 for ‘After RFID.’ RFID technology produced a high amount of output in this specific sub-process. The huge amount of output results in high revenue. The cost estimate for RFID implementation is based on one-year use of RFID. The high cost should go down significantly as RFID tags and readers become cheaper following the normal pattern of other consumer based information technology (e.g., computer chips, cell phones and televisions, etc.) (J. H. Lee, 2005, p. 84).

b. 40th Supply Depot Before RFID

Data analysis obtained from the ‘Before RFID’ inventory process shows that sub-processes that use the existing software (DIS) deliver relatively high total ROI. Even though human cost in sub-processes 3, 5, 7, 8, 9, and 10 have negative impact on the ROI, sub-processes 2 and 6 with most of employees (enlisted men) provide high ROI since their actual output is much more than other sub-processes Subsequently, the total ROI delivers 182% because of these sub-processes showing a high revenue-to-cost ratio. Table 12 shows the ROI of each sub-process.

Table 12. Before RFID Inventory Process

Process(Before RFID)	Human			IT			Total
	Revenue	Cost	ROI	Revenue	Cost	ROI	ROI
1. Print inventory worksheets	$ 36,118	$ 4,816	650%	$ 18,059	$ 25,000	-28%	82%
2. Conduct inventory of items	$ 2,975,690	$ 743,923	300%	$ -	$ -		300%
3. Record count on worksheet	$ 6,567	$ 175,118	-96%	$ -	$ -		-96%
4. Manually input worksheet data into computer	$ 65,669	$ 21,890	200%	$ 32,835	$ 25,000	31%	110%
5. Print inventory discrepancy report	$ 14,447	$ 48,157	-70%	$ 7,224	$ 25,000	-71%	-70%
6. Conduct recount	$ 135,259	$ 16,907	700%	$ -	$ -		700%
7. Record count on inventory worksheets	$ 657	$ 4,378	-85%	$ -	$ -		-85%
8. Manually input data input from recount worksheet	$ 3,283	$ 109	2900%	$ 1,642	$ 25,000	-93%	-80%
9. Print final inventory discrepancy report	$ 328	$ 2,189	-85%	$ 164	$ 25,000	-99%	-98%
10. Print master inventory listing	$ 328	$ 2,189	-85%	$ 164	$ 25,000	-99%	-98%
Total	$ 3,238,347	$ 1,019,676	218%	$ 60,087	$ 150,000	-60%	182%

*** Sub-processes that are eliminated with RFID are 2, 3, 4, 6, 7, and 8.**

According to the above data analysis, the sub-processes that show minimal ROK and ROI could be potential areas for improvement. For example, the performance of sub-processes 3 and 7 were highly improved after the implementation of RFID (see Table 13).

c. *40th Supply Deport After RFID*

The following data analysis shows the ROK and ROI based on real post-RFID implementation data, as the 40th Supply Depot implemented the RFID system in 2005.[4] Sub-processes 3 and 7 delivered low ROK and ROI before RFID was implemented. With the RFID technology implemented, the two sub-processes were integrated with sub-processes 2 and 4. With the implementation of RFID, the 40th Supply Depot decreased processing time by 41% in 'After RFID' and, more importantly, reduced its labor force from 56 employees to 18 employees because RFID replaced those

[4] 'After RFID' data is based on the real data since the 40th Supply Depot has used RFID for five years. However, 'Before RFID' data relies on the memory of Subject Matter Expert (SME).

employees. Furthermore, the technology also enhanced the frequency and accuracy of the inventory output process. Table 13 depicts the ROK and ROI on each sub-process of ‘Before and After RFID.’

Table 13. Comparison Total ROK (Human & IT)

Process	Total(Human & IT)							
	Before RFID				After RFID			
	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Print inventory worksheets	$ 54,177	$ 29,816	182%	82%	$ 76,392	$ 44,290	172%	72%
2. Conduct inventory of items	$ 2,975,690	$ 743,923	400%	300%				
3. Record count on worksheet	$ 6,567	$ 175,118	4%	-96%	$3,439,097	$ 290,855	1182%	1082%
4. Manually input worksheet data into computer	$ 98,504	$ 46,890	210%	110%				
5. Print inventory discrepancy report	$ 21,671	$ 73,157	30%	-70%	$ 27,779	$ 99,229	28%	-72%
6. Conduct recount	$ 135,259	$ 16,907	800%	700%				
7. Record count on inventory worksheets	$ 657	$ 4,378	15%	-85%	$ 151,438	$ 31,593	479%	379%
8. Manually input data input from recount worksheet	$ 4,925	$ 25,109	20%	-80%				
9. Print final inventory discrepancy report	$ 493	$ 27,189	2%	-98%	$ 694	$ 40,586	2%	-98%
10. Print master inventory listing	$ 493	$ 27,189	2%	-98%	$ 694	$ 40,586	2%	-98%
Total	$ 3,298,434	$ 1,169,676	282%	182%	$3,696,095	$ 547,140	676%	576%

***Sub-processes 2, 3, 4 and 6, 7, 8 in ‘Before RFID’ are integrated into sub-process 2 and sub-process 4 of 'After RFID' respectively .**

Implementation of RFID at the 40th Supply Depot reduced total cost due to huge labor cost saving while total revenue increased. It led to 394% ROI increase from ‘Before RFID’; total revenue increased to 1.12 times whereas human cost decreased to 2.8 times. On top of that, IT output increased to 27 times whereas IT cost increased to 1.25 times. To sum up, the ROI increases from a ‘Before RFID’ of 182% to an ‘After RFID’ 576%. This is a total improvement of 394% in ROI.

The estimate is based on the performance of one supply depot. There are four more supply depots in the RoK Air Force. Accordingly, the obtainable revenue from four more facilities through RFID implementation should increase in spite of IT cost increase. IT cost used in the above worksheet was based on a one-year cost through amortizing the total IT cost over the fifteen-year life cycle and taking into account Net Present Value (NPV). Considering the potential precipitous decrease of RFID cost, the ROI through RFID in the 40th Supply Depot should exceed current ROI.

The reason that sub-process 4 delivers lower ROI than sub-process 2 despite the same IT (RFID) cost is that sub-process 4 is performed 17 times in a year whereas sub-process 2 is done 372 times in a year, which results in higher revenue to cost.

B. COMPARATIVE ANALYSIS

1. Two Case Studies in the MND: ASW and 40th Supply Depot

This study provides ROI hurdle rates as shown in Table 14 and IT ROI comparison as shown in Table 15 from the two case studies in the MND.

From both the ASW and the 40th Supply Depot case studies for similar kinds of warehouse logistic operations that have the potential to improve using RFID technology, the authors can set a notional improvement range from 272% to 394%.[5] Table 15 shows the aggregate ROIs from both cases before and after RFID implementation.

Table 14. Hurdle Rate of ROI from Two Case Studies

Process	ASW case study			40th Supply Depot case study		
	Before RFID ROI	After RFID ROI	ROI Gap	Before RFID ROI	After RFID ROI	ROI Gap
Total	338%	610%	272%	182%	576%	394%

Hence, this range value can provide an expected performance improvement range when the decision-makers consider expanding the implementation of RFID to other MND logistic operations that might use RFID.

Comparison of IT ROI improvement based on this research can also be useful to decision-makers who want to estimate the ROI of implemented IT and prospective IT investment. Table 15 shows the comparison of ROI on IT of the two facilities in this study.

[5] ROI of 272% is calculated by subtracting ROI of 338% from ROI of 610% in ASW case and ROI of 394% is calculated by subtracting ROI of 182% from ROI of 576% in the 40th Supply Depot case.

Table 15. Comparison of IT(RFID) ROI from Two Case Studies

Process	ASW case study			40th Supply Depot case study		
	Before RFID ROI	After RFID ROI	ROI Gap	Before RFID ROI	After RFID ROI	ROI Gap
Total	60%	239%	179%	-60%	765%	825%

In the case of ASW, the difference of the ROI between before and after RFID is 179%, which is comparatively low compared to the 40th Supply Depot case. However, the numerical values in both cases show the increasing ROI rate with RFID implementation.

As for the 40th Supply Depot, the remarkable increase of IT ROI was caused by the fact that the output in sub-processes 2, 3, and 4 in ‘Before RFID’ was transferred to sub-process 2 ‘After RFID’ was implemented; likewise, the outputs of sub-processes 6, 7, and 8 in ‘Before RFID’ were transferred to sub-process 4 of the implementation of RFID. This means that even though the employees were reduced in ‘After RFID,’ their outputs were produced by the RFID technology. This contributed to the increase of 6.6 times IT revenue from $60,087 to $396,095 with IT cost increasing 1.26 times from $150,000 to $188,494.

2. Comparison of the Current Study to Previous RFID-based Research at the Naval Postgraduate School (NPS)

The two previously reviewed prior studies were by Courtney (2007) and analyzed almost the same processes as those found in the ASW case and Obellos et al.; (2007) study examined very similar processes to the 40th Supply Depot. Table 16 shows the comparison of the projected ROIs from the previous studies and actual ROIs from the current study.

Table 16. Comparison of Overall ROI between the MND and NPS Case Studies

ROI	ASW		Item-Level		40th Supply Depot		RFID/UID	
	Before	After	Before	After	Before	After	Before	After
	338%	610%	-73%	44%	182%	576%	-79%	133%
Gap	272%		117%		394%		212%	

The overall ROIs of the MND cases were based on real data for ‘To-Be.’ It was almost two times that of NPS projected ROIs for ‘To-Be’ models. Accordingly, the authors may assume that the students at NPS projected the benefit for the ‘To-Be’ model too conservatively. The ROI projected by the previous NPS research actually may reach the ROI that the authors provided from their research. Decision makers who might operate on the basis of the ROI estimates from the prior two studies may expect even higher ROIs based on the real ROIs from RFID implementations from the current study.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

With the MND defense budget decreasing, it is important that military decision-makers find the methods to evaluate new IT acquisition projects. This shrinking defense budget forces the MND to find new ways to make current processes more efficient. RFID has the potential to improve core logistics processes. This study provides a representative example to demonstrate a new approach to estimate its potential ROI.

However, the problem has been how to measure and demonstrate the benefit of RFID objectively. For these reasons, the leadership of the MND should use valid and reliable methods to quantify the actual benefits and projected benefits of new technology investments. Such methods can ensure that the defense budget is prudently being used. Within this context, the use of the KVA as a methodology to evaluate the benefit of RFID implementation is promising. As detailed in the literature review, the KVA is arguably more objective than the alternative (BSC) that the MND has used in the past to evaluate RFID. Over 150 fifty organizations in the public and private sectors have applied KVA for the past 17 years to provide new performance information enabling innovative perspectives for the decision makers (Rios et al, 2006, p. 9). The authors have demonstrated how it can be used to evaluate RFID in the MND, and potentially, throughout the MND to evaluate future IT acquisitions.

Using the two case studies with the KVA methodology, the authors examined the following objectives.

1. Introducing and Applying KVA Theory as a Framework

Since 2005, the MND has used RFID technology in the Ammunition Storage Warehouse and in the 40th Supply Depot. Even though the MND has had a Performance Evaluation Conference (PEC) to measure the performance improvement by the implementation of RFID, the authors believe that it did not have an objective way to estimate the ROI. The only approach used to attempt to estimate the ROI on RFID was the BSC approach. However, the BSC approach is not designed to estimate the ROI.

The most important feature of the KVA is that it can quantify the value resident in human and IT assets in terms of common units of output. With common units of output, it becomes possible to compare the performance of all productive assets including IT.

The authors got the necessary data for the KVA analysis through a KVA survey for data collection (See Appendix III), which took two to three weeks. It took three to four weeks for the authors to analyze the performance for RFID through KVA methodology based on the survey results, which means the total cycle time for performing analysis and interpreting data was six to eight weeks. Given the MND leadership's impatience with time-consuming performance measurement efforts, this indicated that the technique would be feasible to use on a variety of processes that might use RFID technology within a reasonable cycle time.

2. Providing Hurdle Rate

The authors were able to develop the preliminary bases for a notional hurdle rate from the two case studies for the ROI expectation using RFID technology. However, many more studies are required to develop a portfolio of projects from which a more precise hurdle rate could be derived per the prior discussion of hurdle rate in Chapter IV.

As an example of how a hurdle rate for such projects might be developed, the authors combined the results from both studies into a single ROI estimate of 209%. That is the ROI of 209% that is the baseline return without using RFID technology. Multiple 'Before RFID' ROI estimates would provide the volatility information required to develop an eventual hurdle rate. The 'After RFID' implementation ROI estimate of 380% could be used to set expectations for the kind of improvement to expect from using RFID technology.

Table 17. Aggregate ROI

	Before			After			Gap ROI
	Revenue	Cost	ROI	Revenue	Cost	ROI	
ASW 40th SD	$4,362,038	$1,412,468	209%	$6,501,414	$942,428	589%	380%

The hurdle rate could be developed after doing numerous studies that could be used as a reference point for decision-makers of the MND when considering future investments in RFID technology to improve logistics processes.

3. Comparing the ROI Based on the Real Data by Using KVA

One of the unique aspects of this research is that it is based on the real RFID implementation data, not projected data like the previous two studies performed at NPS. As mentioned before, the MND adopted RFID in 2005 and it has entered the stable state in perspective of managing inventories using RFID. These results also suggested that projected improvement from RFID technology in the DoD may be overly conservative.

B. RECOMMENDATIONS AND LIMITATIONS

1. Expansion of RFID Technology

The two processes analyzed by the authors provide limited support for the idea that the MND should continue to use RFID technology to improve current logistics processes that may benefit from implementation of this technology. Specifically, as it was analyzed in this project, the KVA has shown a noticeably increased ROI after using RFID in the inventory checking process at the 40th Supply Depot and in the ASW inventory process. However, more research is needed to assess the impact of RFID across the MND before definitive conclusions can be drawn.

2. Introduction of KVA Methodology to Measure the ROI

The authors recommend the use of the KVA methodology because it is simple and fast to use and generates defensible ROI estimates. Although its application was difficult enough that the initial scope of this research needed to be redefined, the authors believe that, once learned, the application of KVA is simple and fast, compared to other alternatives they might have tried. In addition, considering that the MND is a non-profit organization, the KVA can be a good tool since it can provide a common unit of output that can be used to determine the value added of various technologies in the public sector.

For these reasons, the KVA provides a viable option to estimate the ROI of new IT such as RFID. Hence, the authors recommend that the MND use KVA as a framework to estimate the ROI of IT as well as the ROI on core-processes in general.

"No measurement methodology, however useful, can replace the creative insights, judgments and intuition of managers and investors. KVA is no exception to this rule and should be used as a decision support tool"(Housel, & Bell, 2001, p. 106). According to this statement, the use of KVA should have a primary goal to "establish a common framework within the DoD [and the MND] for understanding, evaluating, and in the end justifying the impact of government investments" into existing as well as future projects and programs for the two organizations (Rios, 2005, p. 46).

3. Further Research Using KVA+RO (Real Options) Framework

From the perspective of the MND, it is important to manage these IT portfolios that include IT such as RFID technology investments and GPS system investments. IT portfolio management is designed to maximize the benefit and minimize the risk of IT investments.

Housel and Mun created the KVA+RO valuation framework, which can express the uncertainty and risks in the potential value of IT options and which provides a way to reduce the risks through analyzing potential strategic investments over time (Seaman, Housel, & Mun, 2008, p. 47). The authors analyzed the ROI of RFID, which can be used as the historical data set necessary to perform the RO analysis to find the most valuable, and least risky, options.

If the MND applied the KVA+RO framework to manage its IT portfolio, it could come up with better investment options. The MND can achieve effective and efficient use of the defense budget by this analytical process.

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APPENDIX I

A. ‘BEFORE RFID’ IN ASW

Process		Number of Employees(Total	Rank of Difficulty	RLT(hr)	ALT(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process: Human	Knowledge(hr)/ Process: IT	Total K/Yr	Human Cost/Yr	IT cost/Yr	Automation Tools
1. Sending Requirement Paper (R.P.) of Ammo.		5	11	20	3	50%	84	0.5	15	7.5	1890	$ 5,373	$16,667	Software Program
2. Receiving R.P. & Drawing up A.P.(Approving Pap		7	10	22	3	50%	84	0.5	21	10.5	2646	$ 7,191	$16,667	Software Program
3. Transmitting the A.P through wireless system		4	9	22	3	50%	84	0.17	12	6	1512	$ 1,318	$16,667	Software Program
4. Proceed to ASP		2	3	5	0.5	30%	84	0.08	1	0.3	109.2	$ 310	$100,000	Gate Checking Program
5. Designating & A.S Arri	Designating ASW	4	8	7	1	50%	84	0.5	4	2	504	$ 3,859	$16,667	Software Program
	A.S Arrival	1	2	3	0.5	0%	84	0.3	0.5	0	42	$ 254	$0	
6. Movement to A.S.W		3	1	3	0.5	0%	84	0.3	1.5	0	126	$ 2,061	$0	
7. Loading ammo.		8	7	3	1	0%	84	1.5	8	0	672	$ 16,666	$0	
8. Confirm	Signing to confirm (Comp	4	4	3	0.5	50%	84	0.2	2	1	252	$ 1,544	$16,667	Software Program
	Signing to confirm (Batalli	6	5	4	0.5	50%	84	0.2	3	1.5	378	$ 2,277	$16,667	Software Program
9. Return to Base		2	6	8	0.5	0%	84	0.5	1	0	84	$ 1,938	$0	
Total		46		100	14		924	4.75			8215.2	$ 42,792	$200,000	

Process		Human: Revenue	Human: Cost	Human: ROK	Human: ROI	IT: Revenue	IT: Cost	IT: ROK	IT: ROI	Total: Revenue	Total: Cost	Total: ROK	Total: ROI
1. Sending Requirement Paper (R.P.) of Ammo.		$ 161,201	$ 5,373	3000%	2900%	$ 80,600	$ 16,667	484%	384%	$ 241,801	$ 22,040	1097%	997%
2. Receiving R.P. & Drawing up A.P.(Approving Pap		$ 302,008	$ 7,191	4200%	4100%	$ 151,004	$ 16,667	906%	806%	$ 453,012	$ 23,857	1899%	1799%
3. Transmitting the A.P through wireless system		$ 93,035	$ 1,318	7059%	6959%	$ 46,517	$ 16,667	279%	179%	$ 139,552	$ 17,985	776%	676%
4. Proceed to ASP		$ 3,876	$ 310	1250%	1150%	$ 1,163	$ 100,000	1%	-99%	$ 5,039	$ 100,310	5%	-95%
5. Designating & A.S Arri	Designating ASW	$ 30,873	$ 3,859	800%	700%	$ 15,437	$ 16,667	93%	-7%	$ 46,310	$ 20,526	226%	126%
	A.S Arrival	$ 424	$ 254	167%	67%	$ -	$ -			$ 424	$ 254	167%	67%
6. Movement to A.S.W		$ 10,305	$ 2,061	500%	400%	$ -	$ -			$ 10,305	$ 2,061	500%	400%
7. Loading ammo.		$ 88,885	$ 16,666	533%	433%	$ -	$ -			$ 88,885	$ 16,666	533%	433%
8. Confirm	Signing to confirm (Comp	$ 15,437	$ 1,544	1000%	900%	$ 7,718	$ 16,667	46%	-54%	$ 23,155	$ 18,210	127%	27%
	Signing to confirm (Batalli	$ 34,162	$ 2,277	1500%	1400%	$ 17,081	$ 16,667	102%	2%	$ 51,244	$ 18,944	270%	170%
9. Return to Base		$ 3,876	$ 1,938	200%	100%	$ -	$ -			$ 3,876	$ 1,938	200%	100%
Total		$ 744,083	$ 42,792	1739%	1639%	$ 319,521	$ 200,000	160%	60%	$ 1,063,604	$ 242,792	438%	338%

CORRELATION: *Order of Difficulty to Actual Learning Time* 0.84338

CORRELATION: *Relative Learning Time to Actual Avg Training* 0.967057

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E	$3,000	$1.44	$ 21,000.00	$10.10
S 1	$15,640	$7.52	$ 23,460.00	$11.28
S 2	$26,490	$12.74	$ 39,735.00	$19.10
S 3	$37,695	$18.12	$ 56,542.50	$27.18
S 4	$49,422	$23.76	$ 74,133.00	$35.64
WO	$49,992	$24.03	$ 74,988.00	$36.05
O 1	$18,984	$9.13	$ 28,476.00	$13.69
O 2	$20,683	$9.94	$ 31,024.50	$14.92
O 3	$30,000	$14.42	$ 45,000.00	$21.63

Knowledge(%): Human	Knowledge(%): IT
66.67%	33.33%
66.67%	33.33%
66.67%	33.33%
76.92%	23.08%
66.67%	33.33%
100.00%	0.00%
100.00%	0.00%
100.00%	0.00%
66.67%	33.33%
66.67%	33.33%
100.00%	0.00%

Note : Hourly wage = Base Pay /(260 working days in a year * 8 working hours per day)

	E	S2	S3	S4	WO	O1	O2	O3
Yearly Salary	$3,000	$26,490	$37,695	$49,422	$49,992	$18,984	$20,683	$30,000
Yearly Salary/hr	$1.44	$12.74	$18.12	$23.76	$24.03	$9.13	$9.94	$14.42
Mkt revenue/hr	$10.10	$11.28	$27.18	$35.64	$36.05	$13.69	$14.92	$21.63

B. 'AFTER RFID' IN ASW

Process		Number of Employees	Rank of Difficulty	RLT(hr)	ALT(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process Human	Knowledge(hr)/ Process IT	Total K/Yr	Human Cost/Yr	IT cost/Yr	Automation Tools
1. Sending Requirement Paper (R.P.) of Ammo.		5	8	20	3	70%	168	0.5	15	10.5	4284	$ 10,747	$ 20,000	Software Program
2. Receiving R.P. & Drawing up A.P.(Approving Pape		7	9	20	3	70%	168	0.5	21	14.7	5997.6	$ 14,381	$ 20,000	Software Program
3. Transmitting the A.P through wireless system		4	6	16	3	70%	168	0.17	12	8.4	3427.2	$ 2,636	$ 20,000	Software Program
4. Proceed to ASP		2	3	2	0.5	30%	168	0.08	1	0.3	218.4	$ 620	$ 100,000	Gate Checking Program
5. Designating & A.S Arriv	Designating ASW	0	-	0	0	0%	0	0	0	0	0	$ -	$ -	-
	A.S Arrival	1	4	3	1.5	70%	168	0.08	1.5	1.05	428.4	$ 136	$ 20,000	Software Program
6. Movement to A.S.W		3	2	3	0.5	0%	168	0.08	1.5	0	252	$ 1,099	$ -	-
7. Loading ammo. And Real Information transmitting		8	7	9	1	80%	168	0.83	8	6.4	2419.2	$ 18,444	$ 139,477	RFID
8. Confirm	Signing to confirm (Compa	0	-	0	0	0%	0	0	0	0	0	$ -	$ -	-
	Signing to confirm (Batallic	6	5	24	1	70%	168	0.17	6	4.2	1713.6	$ 3,872	$ 20,000	Software Program
9. Return to Base		2	1	3	0.5	0%	168	0.5	1	0	168	$ 3,876	$ -	
Total		38		100	14		1512	2.91			18,908.40	$ 55,811	$ 339,477	

Process		Human Revenue	Human Cost	Human ROK	Human ROI	IT Revenue	IT Cost	IT ROK	IT ROI	Total Revenue	Total Cost	Total ROK	Total ROI
1. Sending Requirement Paper (R.P.) of Ammo.		$ 322,409	$ 10,747	3000%	2900%	$ 225,686	$ 20,000	1128%	1028%	$ 548,095	$ 30,747	1783%	1683%
2. Receiving R.P. & Drawing up A.P.(Approving Pape		$ 604,029	$ 14,381	4200%	4100%	$ 422,820	$ 20,000	2114%	2014%	$ 1,026,849	$ 34,381	2987%	2887%
3. Transmitting the A.P through wireless system		$ 186,077	$ 2,636	7059%	6959%	$ 130,254	$ 20,000	651%	551%	$ 316,331	$ 22,636	1397%	1297%
4. Proceed to ASP		$ 7,753	$ 620	1250%	1150%	$ 2,326	$ 100,000	2%	-98%	$ 10,079	$ 100,620	10%	-90%
5. Designating & A.S Arriv	Designating ASW	$ -	$ -	0%	0%	$ -	$ -			$ -	$ -		
	A.S Arrival	$ 25,701	$ 136	18941%	18841%	$ 17,991	$ 20,000	90%	-10%	$ 43,693	$ 20,136	217%	117%
6. Movement to A.S.W		$ 20,611	$ 1,099	1875%	1775%	$ -	$ -			$ 20,611	$ 1,099	1875%	1775%
7. Loading ammo.		$ 177,771	$ 18,444	964%	864%	$ 142,217	$ 139,477	102%	2%	$ 319,988	$ 157,921	203%	103%
8. Confirm	Signing to confirm (Compa	$ -	$ -	0%	0%	$ -	$ -			$ -	$ -		
	Signing to confirm (Batallic	$ 301,130	$ 3,872	7778%	7678%	$ 210,791	$ 20,000	1054%	954%	$ 511,921	$ 23,872	2144%	2044%
9. Return to Base		$ 7,753	$ 3,876	200%	100%	$ -	$ -			$ 7,753	$ 3,876	200%	100%
Total		$ 1,653,234	$ 55,811	2962%	2862%	$ 1,152,085	$ 339,477	339%	239%	$ 2,805,319	$ 395,288	710%	610%

CORRELATION:	*Order of Difficulty to Relative Learning Time*	0.749227
CORRELATION:	*Relative Learning Time to Actual Avg Training*	0.755667

C. LCC OF RF-AIS IN ASW

	Total	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	Total	% of Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Year		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		
Acquision cost	$ 29,881,818	$ 5,976,364	$ 5,976,364	$ 5,976,364	$ 5,976,364	$ 5,976,364	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 29,881,818	77.69%
RDTE	$ 8,081,818	$ 8,081,818	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,081,818	18.88%
Operations & Maintenance	$ 496,836	$ -	$ 26,713	$ 27,515	$ 28,340	$ 29,190	$ 30,066	$ 30,968	$ 31,897	$ 32,854	$ 33,839	$ 34,855	$ 35,900	$ 36,977	$ 38,087	$ 39,229	$ 40,406	$ 496,836	1.53%
Total (Then Year)	$ 38,460,472	$ 14,058,182	$ 6,003,077	$ 6,003,878	$ 6,004,704	$ 6,005,554	$ 30,066	$ 30,968	$ 31,897	$ 32,854	$ 33,839	$ 34,855	$ 35,900	$ 36,977	$ 38,087	$ 39,229	$ 40,406	$ 38,460,472	98.11%
Inflation adjusted (Then Year)	$ 42,802,598	$ 14,620,509	$ 6,492,928	$ 6,753,546	$ 7,024,654	$ 7,306,674	$ 38,043	$ 40,752	$ 43,653	$ 46,761	$ 50,091	$ 53,657	$ 57,477	$ 61,570	$ 65,954	$ 70,650	$ 75,680	$ 42,802,598	
PV (FY 2005)	$ 32,437,915	$ 13,171,630	$ 5,269,806	$ 4,938,135	$ 4,627,357	$ 4,336,156	$ 20,339	$ 19,628	$ 18,942	$ 18,280	$ 17,641	$ 17,024	$ 16,429	$ 15,855	$ 15,301	$ 14,766	$ 14,250	$ 32,437,915	
Cumulative PV (FY2005)		$ 13,171,630	$ 18,441,436	$ 23,379,571	$ 28,006,928	$ 32,343,083	$ 32,363,423	$ 32,383,051	$ 32,401,993	$ 32,420,273	$ 32,437,915	$ 32,454,939	$ 32,471,368	$ 32,487,224	$ 32,502,524	$ 32,517,291	$ 32,531,540	$ 64,969,455	

Total Inflated	$ 42,802,598
Total PV	$ 32,437,915

Inflation rate = 4%

Discount rate = 8%

Systems Built	Total 7 Units
Total LCC	$ 32,437,915
LCC per Unit	$ 4,633,988
LCC per YR of Unit	$ 308,933

※ Assumptions

Life Cycle : 1 yr of R&D + 15 yrs of O&M

Total 7 units for Implemenation

From '05 7. Logistics Management Deparement

Total	RFID Reader / Tag	Computet Facility / Installation cost	RF-AIS software RDTE cost
$ 37,963,636	$ 24,881,818	$ 5,000,000	$ 8,081,818

From '06 KNDU Thesis "An Economic Analysis for RFID Pilot Project in the Defense Ammunition Field"

(Operations & Maintenance Cost)

FY	Cost	
2006	$ 26,713	₩ 29,384,465
2007	$ 27,515	₩ 30,265,999
2008	$ 28,340	₩ 31,173,979
2009	$ 29,190	₩ 32,109,198
2010	$ 30,066	₩ 33,072,474
2011	$ 30,968	₩ 34,064,648
2012	$ 31,897	₩ 35,086,588
2013	$ 32,854	₩ 36,139,186
2014	$ 33,839	₩ 37,223,361
2015	$ 34,855	₩ 38,340,062

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APPENDIX II

A. ‘BEFORE RFID’ IN THE 40TH SUPPLY DEPOT

Process	Number of employess	Rank of Difficulty	RLT(hr)	ALT(hr)	% Auto	Times performed in a year	Average Time to complete	Knowledge(hr)/ Process		Total K/Yr(Hr)	Human Cost/Yr	IT cost/Yr	Automation Tool
								Human	IT				
1. Print inventory worksheets	3	2	2	0.5	50%	264	0.2	1.5	0.75	594	$ 4,816	$ 25,000	software program
2. Conduct inventory of items	16	10	40	2	0%	264	8	32	0	8448	$ 743,923	$ -	
3. Record count on worksheet	3	7	4	0.1	0%	240	8	0.3	0	72	$ 175,118	$ -	
4. Manually input worksheet data into computer	3	6	4	1	50%	240	1	3	1.5	1080	$ 21,890	$ 25,000	software program
5. Print inventory discrepancy report	3	3	1	0.2	50%	264	2	0.6	0.3	237.6	$ 48,157	$ 25,000	software program
6. Conduct recount	16	9	40	2	0%	12	4	32	0	384	$ 16,907	$ -	
7. Record count on worksheet	3	5	4	0.2	0%	12	4	0.6	0	7.2	$ 4,378	$ -	
8. Manually input data input from recount worksheet	3	4	1	1	50%	12	0.1	3	1.5	54	$ 109	$ 25,000	software program
9. Print final inventory discrepancy report	3	2	2	0.1	50%	12	2	0.3	0.15	5.4	$ 2,189	$ 25,000	software program
10. Print master inventory listing	3	1	2	0.1	50%	12	2	0.3	0.15	5.4	$ 2,189	$ 25,000	software program
Total	56		100	7.2		1332	31.3			10887.6	$ 1,019,676	$ 150,000	

Process	Human				IT				Total			
	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Print inventory worksheets	$ 36,118	$ 4,816	750%	650%	$ 18,059	$ 25,000	72%	-28%	$ 54,177	$ 29,816	182%	82%
2. Conduct inventory of items	$ 2,975,690	$ 743,923	400%	300%	$ -	$ -			$ 2,975,690	$ 743,923	400%	300%
3. Record count on worksheet	$ 6,567	$ 175,118	4%	-96%	$ -	$ -			$ 6,567	$ 175,118	4%	-96%
4. Manually input worksheet data into computer	$ 65,669	$ 21,890	300%	200%	$ 32,835	$ 25,000	131%	31%	$ 98,504	$ 46,890	210%	110%
5. Print inventory discrepancy report	$ 14,447	$ 48,157	30%	-70%	$ 7,224	$ 25,000	29%	-71%	$ 21,671	$ 73,157	30%	-70%
6. Conduct recount	$ 135,259	$ 16,907	800%	700%	$ -	$ -			$ 135,259	$ 16,907	800%	700%
7. Record count on inventory worksheets	$ 657	$ 4,378	15%	-85%	$ -	$ -			$ 657	$ 4,378	15%	-85%
8. Manually input data input from recount worksheet	$ 3,283	$ 109	3000%	2900%	$ 1,642	$ 25,000	7%	-93%	$ 4,925	$ 25,109	20%	-80%
9. Print final inventory discrepancy report	$ 328	$ 2,189	15%	-85%	$ 164	$ 25,000	1%	-99%	$ 493	$ 27,189	2%	-98%
10. Print master inventory listing	$ 328	$ 2,189	15%	-85%	$ 164	$ 25,000	1%	-99%	$ 493	$ 27,189	2%	-98%
Total	$ 3,238,347	$ 1,019,676	318%	218%	$ 60,087	$ 150,000	40%	-60%	$ 3,298,434	$ 1,169,676	282%	182%

Correlation	Rank of Difficulty to Relative LT	0.819208223
Correlation	Relative LT to Actual ALT	0.88536444

Pay Grade	Mil Salary/Yr	Mil salary/Hr	Mkt Comp Rev/Yr	Mkt comparable Revenue/Hr
E	$3,000	$1.44	$ 21,000.00	$10.10
S2	$26,490	$12.74	$ 39,735.00	$19.10
S3	$37,695	$18.12	$ 56,542.50	$27.18
S4	$49,422	$23.76	$ 74,133.00	$35.64
WO	$49,992	$24.03	$ 74,988.00	$36.05

Note : Hourly wage = Base Pay /(260 working days in a year * 8 working hours per day)

	E	S2	S3	S4	WO
Yearly Salary	$3,000	$26,490	$37,695	$49,422	$49,992
Yearly Salary/hr	$1.44	$12.74	$18.12	$23.76	$24.03
Mkt Comp Rev/hr	$10.10	$19.10	$27.18	$35.64	$36.05

Knowledge(%)	
Human	IT
67%	33%
100%	0%
100%	0%
67%	33%
67%	33%
100%	0%
100%	0%
67%	33%
67%	33%
67%	33%

B. ‘AFTER RFID’ IN THE 40TH SUPPLY DEPOT

Process	Number of employess	Rank of Difficulty	Relative learning	Actual Average	% Auto	Times performed in a	Average Time to	Knowledge(hr)/ Process Human	Knowledge(hr)/ Process IT	Total K/Yr	Human Cost/Hr	IT cost/Yr	Automation Tool
1. Print inventory worksheets	3	1	2	0.5	50%	372	0.2	1.5	0.75	837.54	$ 91	$ 37,500	software program
2. Conduct inventory with PDA & Transfer data wirelessly to Comp	3	6	40	3.2	80%	372	8	9.6	7.68	6432.3072	$ 91	$ 19,247	RFID
3. Print inventory discrepancy report	3	2	2	0.2	50%	338	2	0.6	0.3	304.56	$ 91	$ 37,500	software program
4. Reconduct inventory with PDA & Transfer data wirelessly to Con	3	5	52	3.1	80%	17	8	9.3	7.44	283.2408	$ 91	$ 19,247	RFID
5. Print final inventory discrepancy report	3	3	2	0.1	50%	17	2	0.3	0.15	7.614	$ 91	$ 37,500	software program
6. Print master inventory listing	3	4	2	0.1	50%	17	2	0.3	0.15	7.614	$ 91	$ 37,500	software program
Total	18		100	7.2		1134	22.2			7872.876	$ 547	$ 188,494	

Process	Human				IT				Total			
	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI	Revenue	Cost	ROK	ROI
1. Print inventory worksheets	$ 50,928	$ 6,790	750%	650%	$ 25,464	$ 37,500	68%	-32%	$ 76,392	$ 44,290	172%	72%
2. Conduct inventory with PDA & Transfer data wirelessly to Comp	$ 1,910,610	$ 271,608	703%	603%	$ 1,528,488	$ 19,247	7941%	7841%	$ 3,439,097	$ 290,855	1182%	1082%
3. Print inventory discrepancy report	$ 18,519	$ 61,729	30%	-70%	$ 9,260	$ 37,500	25%	-75%	$ 27,779	$ 99,229	28%	-72%
4. Reconduct inventory with PDA & Transfer data wirelessly to Con	$ 84,132	$ 12,346	681%	581%	$ 67,306	$ 19,247	350%	250%	$ 151,438	$ 31,593	479%	379%
5. Print final inventory discrepancy report	$ 463	$ 3,086	15%	-85%	$ 231	$ 37,500	1%	-99%	$ 694	$ 40,586	2%	-98%
6. Print master inventory listing	$ 463	$ 3,086	15%	-85%	$ 231	$ 37,500	1%	-99%	$ 694	$ 40,586	2%	-98%
Total	$ 2,065,115	$ 358,646	576%	476%	$ 1,630,980	$ 188,494	865%	765%	$ 3,696,095	$ 547,140	676%	576%

Correlation	Rank of Difficulty to Relative LT	0.788921861
Correlation	Relative LT to Actual ALT	0.978079067

C. LCC OF RFID IN THE 40TH SUPPLY DEPOT

Year	Total	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08
		1	2	3	4	5	6	7	8
		2005	2006	2007	2008	2009	2010	2011	2012
Acquision cost	$ 312,500		$ 312,500						
RDTE	$ 312,500	$ 312,500							
Operations & Maintenance	$ 25,000		$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667
Total (Then Year)	$ 650,000	$ 312,500	$ 314,167	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667
Inflation adjusted (Then Year)	$ 699,096	$ 325,000	$ 339,803	$ 1,875	$ 1,950	$ 2,028	$ 2,109	$ 2,193	$ 2,281
PV (FY 2005)	$ 577,413	$ 292,793	$ 275,791	$ 1,371	$ 1,284	$ 1,203	$ 1,127	$ 1,056	$ 990
Cumulative PV (FY2005)		$ 292,793	$ 568,584	$ 569,955	$571,239	$ 572,443	$ 573,570	$ 574,627	$ 575,616

Year	FY09	FY10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	Total	% of Total
	9	10	11	12	13	14	15	16		
	2013	2014	2015	2016	2017	2018	2019	2020		
Acquision cost									$ 312,500	48.08%
RDTE									$ 312,500	48.08%
Operations & Maintenance	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 25,000	3.85%
Total (Then Year)	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 1,667	$ 650,000	100.00%
Inflation adjusted (Then Year)	$ 2,372	$ 2,467	$ 2,566	$ 2,668	$ 2,775	$ 2,886	$ 3,002	$ 3,122	$ 699,096	
PV (FY 2005)	$ 927	$ 869	$ 814	$ 763	$ 715	$ 670	$ 627	$ 588	$ 577,413	
Cumulative PV (FY2005)	$ 576,544	$ 577,413	$ 578,227	$ 578,989	$ 579,704	$580,374	$581,001	$ 581,589	$ 1,159,001	

Total Inflated	$ 699,096
Total PV	$ 577,413

Systems Built	1 Unit
Total LCC	$ 577,413
LCC per Unit	$ 577,413
LCC per YR of Unit	$ 38,494

*** Assumptions**

Discount rate = 8%

Inflation rate = 4%

Life Cycle: 1 yr of R&D

Total 1 unit for implementation

From '05 7. Logistics Management Deparement

Total	RFID Reader / Tag	Computet Facility /	RFID RDTE cost
$ 37,963,636.36	$ 24,881,818.18	$5,000,000.00	$8,081,818.18

From '06 KNDU Thesis "An Economic Analysis for RFID Pilot Project in the Defense Ammunition Field"

(Operations & Maintenance Cost)

FY	Cost	
2006	$ 26,713	₩ 29,384,465
2007	$ 27,515	₩ 30,265,999
2008	$ 28,340	₩ 31,173,979
2009	$ 29,190	₩ 32,109,198
2010	$ 30,066	₩ 33,072,474
2011	$ 30,968	₩ 34,064,648
2012	$ 31,897	₩ 35,086,588
2013	$ 32,854	₩ 36,139,186
2014	$ 33,839	₩ 37,223,361
2015	$ 34,855	₩ 38,340,062

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APPENDIX III

Name: Major. Son, Jongwoo
Job-Title: Director in 40th Supply Depot

*** 해당 내용은 실무부서에서 재고조사 과정에 국한하여 작성한 수치이며, 11 월 2 주차 40 보급창에서 RFID 이용한 업무과정에 대한 실 측정 예정임.**

따라서 추후 실 측정 자료 필요 시 재 연락 바랍니다.(소령 손종우)

The following data are limited to inventory checking process. Further detail data on broad processes using RFID in 40th Supply Depot will be obtainable after 2nd week of November, 2009.

A. **작업절차묘사**: 각 절차는 명확한 input 과 output 이 있어야 한다.

아래의 양식은 예시이기 때문에 현재 40 창에서 RFID 이용한 재고조사 절차(Process)와는 다소 차이가 있음을 고려하여 작업절차를 묘사해 주시길 부탁합니다.

B. **각 절차수행하는 방법를 배우는데 소요되는 예상시간(hrs) (Actual Average Training Period):**

평균인을 교육시켜 각 절차를 수행할 수 있게 교육/훈련키는데 필요한 실제 평균시간(예. 이론교육 2 주, 시범 및 실습 1 주). 이는 신입(Background 가 없는)을 대상으로 주어진 프로세스의 output 을 생산해내는데 필요한 모든것을 배우는데 필요한 시간임.

C. **각 절차 수행에 필요한 인원 (Number of Employees)**: 각 절차에서 일하고 있는 인원

D. **상대적 학습 소요 시간 (Relative Learning Time):** 총 100 시간을 기준으로 각 절차 수행에 소요되는 상대적 분배 시간 (즉, 'D' column 의 총 합은 100 시간)

E. **각 절차 수행에 소요되는 시간 (Average Time to Complete):** 각 절차(Process)에서 훈련된 **한 사람**이 각 임무를 수행하는데 소요되는 예상시간

F. **한 달간 수행 횟수: 각 절차(Process)가 한달간 샐행되는 예상 횟수**: 일일 수행 횟수* 20 일 =

G. **계급 (Pay Grade)**: 각 절차(Process)에 속해있는 고용인(Employees)인들의 계급

H. **각 절차의 난이도 순서 (Rank Order of Difficulty):** 1= 가장쉬운 절차, n=가장 어려움 (총 절차의 개수(n)에 맞게 1 부터 n 까지 표시, 예시에서 n=10)

I. **자동화 (Percentage Automation) %:** 각 절차(Process)의 자동화 정도를 백분율로 표시한 것. %

J. 비고: 각 절차에 해당되는 내용중 추가 설명이 필요한 내용 기입

A. RFID 사용 전 재고조사

	A	B	C	D	E	F	G	H	I	J
절차	작업절차 묘사 (Process Description)	각 절차 수행하는 방법을 배우는데 소요되는 예상시간(hrs) (Actual Average Training Period)	각 절차 수행에 필요한 인원 (Number of Employees)	상대적 학습 소요 시간 (Relative Learning Time)	각 절차 수행에 소요되는 시간 (Average Time to Complete)	한 달간 수행된 횟수 (Times Performed in a month)	계급 (Pay grade)	각 절차의 난이도 순서 (Rank Order of Difficulty)	자동화 % (Percentage Automation)	비고
1	재고 워크시트 출력	0.5	3	2	0.2	22	군무원(2) 중사(1)	2	50%	
2	재고량 조사	2	16	40	8	22	군무원(7) 중사(1) 병장(3),일병(4) 이병(1)	10	0%	
3	재고량 수기기입	0.1	3	4	8	20	군무원(2) 중사(1)	7	0%	
4	재고량 데이터 컴퓨터 입력	1	3	4	1	20	군무원(2) 중사(1)	6	50%	
5	재고수량 차이 리포트 출력	0.2	3	1	0.1	22	군무원(2) 중사(1)	3	50%	
6	수량차이에 대한 재조사	2	16	40	4	1	군무원(7) 중사(1) 병장(3) 일병(4) 이병(1)	9	0%	
7	재조사된 수량 워크시트에 기입	0.2	3	4	4	1	군무원(2) 중사(1)	5	0%	
8	데이터 컴퓨터에 재입력	1	3	1	0.1	1	군무원(2) 중사(1)	4	50%	
9	최종재고수량 차이 리포트	0.1	3	2	0.1	1	군무원(2) 중사(1)	2	50%	

	출력									
10	주 재고목록 리포트 출력	0.1	3	2	0.1	1	군무원(2) 중사(1)	1	50%	

B. RFID 사용 후 재고조사

	A	B	C	D	E	F	G	H	I	J
	작업절차 묘사	각 절차 수행하는 방법을 배우는데 소요되는 예상시간(hrs) (Actual Average Training Period)	각 절차 수행에 필요한 인원 (Number of Employees)	상대적 학습 소요 시간 (Relative Learning Time)	각 절차 수행에 소요되는 시간 (Average Time to Complete)	한 달간 수행된 횟수 (Times Performed in a month)	계 급 (Pay grade)	각 절차의 난이도 순서 (Rank Order of Difficulty)	자동화 % (Percentage Automation)	비 고
1	재고 워크시트 출력	0.5	3	2	0.2	22	군무원(2) 중사(1)	1	50%	
2	PDA 로 재고조사 및 데이터 컴퓨터로 무선 전송	1	3	40	8	22	군무원(2) 중사(1)	6	80%	
3	재고수량 차이 리포트 출력	0.2	3	2	2	20	군무원(2) 중사(1)	2	50%	
4	재고 재조사 및 데이터 컴퓨터로 무선전송	1	3	52	8	1	군무원(2) 중사(1)	5	80%	
5	최종 재고수량 차이 리포트 출력	0.2	3	2	2	1	군무원(2) 중사(1)	3	50%	
6	주 재고목록 리포트 출력	0.2	3	2	2	1	군무원(2) 중사(1)	4	50%	

C. RFID 사용 전 탄약분배절차 (ASW)

	A	B	C	D	E	F	G	H	I
절차	작업절차 묘사 (Process Description)	각 절차 수행하는 방법을 배우는데 소요되는 예상시간(hrs) (Actual Average Training Period)	각 절차 수행에 필요한 인원 (Number of Employees)	상대적 학습 소요 시간 (Relative Learning Time)	각 절차 수행에 소요되는 시간 (Average Time to Complete)	한 달간 수행된 횟수 (Times Performed in a month)	계급 (Pay grade)	각 절차의 난이도 순서 (Rank Order of Difficulty)	자동화 % (Percentage Automation)
1	편성부대 탄약청구	3	5	20	0.5	7	병사 2, 상사 1 준위 2	11	50%
2	탄약창 운영계 수령지시	3	7	22	0.5	7	병사 2, 상사 1 준위 2, 대위 2	10	50%
3	탄약창 도착 및 출입조치	0.5	2	5	0.08	7	병사 1, 준위 1	3	30%
4	운영계에서 불출송증 발급	3	4	22	0.17	7	병사 2, 준위 2	9	50%
5	관리중대에서 현장계 및 대상 탄약고 지정	1	4	7	0.5	7	병사 2, 상사 1 준위 1	8	50%
6	현장계 도착	0.5	1	3	0.3	7	병사 1	2	0%
7	탄약고 이동	0.5	3	3	0.3	7	병사 1, 상사 1 준위 1	1	0%
8	탄약적재	1	8	3	0.15	7	병사 6, 준위 1 대위 1	7	0%
9	관리중대에서 확인 (Company)	0.5	4	3	0.2	7	병사 2, 상사 1 준위 1	4	50%
10	운영계 불출증빙서 날인(Battalion)	0.5	6	4	0.2	7	병사 2, 중사 2 대위 2	5	50%
11	부대복귀	0.5	2	8	0.5	7	병사 1, 준위 1	6	0%
Total		14	46						

D. RFID 사용 후 탄약분배절차 (ASW)

	A	B	C	D	E	F	G	H	I
절차	작업절차 묘사 (Process Description)	각 절차 수행하는 방법을 배우는데 소요되는 예상시간(hrs) (Actual Average Training Period)	각 절차 수행에 필요한 인원 (Number of Employees)	상대적 학습 소요 시간 (Relative Learning Time)	각 절차 수행에 소요되는 시간 (Average Time to Complete)	한 달간 수행된 횟수 (Times Performed in a month)	계급 (Pay grade)	각 절차의 난이도 순서 (Rank Order of Difficulty)	자동화 % (Percentage Automation)
1	편성부대 탄약청구	3	5	20	0.5	168	병사 2, 상사 1 준위 2	8	70%
2	탄약창 운영계 수령지시	3	7	20	0.5	168	병사 2, 상사 1 준위 2, 대위 2	9	70%
3	탄약창 도착 및 출입조치	0.5	2	2	0.08	168	병사 1, 준위 1	3	30%
4	운영계에서 불출송증 발급	3	4	16	0.17	168	병사 2, 준위 2	6	70%
5	관리중대 현장계 도착	1.5	2	3	0.08	168	병사 1	4	0%
6	탄약고 이동	0.5	3	3	0.08	168	병사 1, 상사 1 준위 1	2	0%
7	탄약적재 및 적재상황 PDA 송출	1	8	9	0.83	168	병사 6, 상사 1 준위 1	7	80%
8	운영계 불출증빙서 날인(Battalion)	1	6	24	0.17	168	병사 2, 준위 2 대위 2	5	70%
9	부대복귀	0.5	2	3	0.5	168	병사 1, 준위 1	1	0%
Total		14	39						

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